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BEGINNING ITS FIFTEENTH YEAR WELL.

In THE ELECTRICAL WORLD of Jan. 2, 1886, we drew attention with not a little pride to the fact that that particular issue, consisting of 32 pages, was the largest number of an electrical journal that had up to that time been issued anywhere.

In February and again in August of the same year, however, we were able to point to numbers of still larger proportions, namely, 36 and 44 pages respectively, and this again was fully maintained in 1887, for the number containing the report of the Philadelphia meeting of the National Electric Light Association, in February of that year, consisted of 48 pages, while the number containing the report of the Boston meeting in August following had 56.

Once again THE ELECTRICAL WORLD breaks its own high record, for to-day we have the pleasure and satisfaction of presenting our readers with another banner number, consisting this time of no fewer than sixty-four pages. With this number the paper begins its fifteenth year, and begins it well with such an issue.

BREAKING THE RECORD ONCE MORE.

THE ELECTRICAL WORLD has always taken a warm interest in the National Electric Light Association. When the first Convention took place in Chicago, Feb. 25, 1885, the report of the proceedings was telegraphed in extenso to this journal, in the shape of a special telegram from its resident correspondent and representative, and this telegraphic report occupied no fewer than 4½ columns of solid reading matter, and was published in the issue of the week the Convention was held.

When the second meeting occurred in New York in August of the same year the report published in THE ELECTRICAL WORLD covered 4 pages of space, while the report of the meeting of February, 1886, at Baltimore, filled 8½ pages, and the report of the Detroit meeting, in August of the same year, filled 9 pages. To the report of the Philadelphia meeting of February, 1887, we devoted no fewer than 14½ pages, and to the report of the Boston meeting of August of the same year the still larger number of 19 pages of solid reading matter. Our present report occupies nearly 18 pages, or far more than has been given to any previous Winter meeting of the Association, or leaving out of consideration the large wire gauge table of August last, more than any convention at any time.

Nothing better emphasizes the growing value and importance of these Conventions, and the increasing interest in their proceedings, than the number of pages that we found it necessary to print on the occasion of the different Conventions so far held, in order to meet the demand for a full report of the meetings, as well as the demand for extra advertising space.

The issues containing the reports of the Electric Light Conventions have been the high-water-mark numbers of THE ELECTRICAL WORLD. The following table shows at a glance the number of pages, including both reading matter and advertisements, in each of these issues:

NUMBER OF PAGES IN CONVENTION REPORT NUMBERS.

Chicago meeting, February, 1885	20
New York meeting, August, 1885	24
Baltimore meeting, February, 1886	36*
Detroit meeting, August, 1886	44*
Philadelphia meeting, February, 1887	48*
Boston meeting, August, 1887	56*
Pittsburgh meeting, February, 1888	64*

These figures are interesting and instructive, in so far as they exemplify the progress and development of the electric lighting industry, as well as of electrical applications in general.

THE ELECTRIC LIGHT CONVENTION AT PITTSBURGH.

Our very complete report in this issue of the meeting of the National Electric Light Association at Pittsburgh will show that the convention was one of the most successful held by the body. The attendance was large, the papers and discussions were equally admirable; while inspection of the many industries of the city, as well as its varied applications of natural gas, furnished most agreeable occupation for the leisure hours of the members during the whole week.

It will be seen that the Association has lost the services of Mr. J. F. Morrison as its president. This was expected, and has been commented upon by us in advance, but the occasion is fitting for the remark that Mr. Morrison did work entitling him to the heartiest thanks of all, and to recognition which could certainly take no less pronounced form than it did in the resolutions adopted with cheers. In President Duncan the association has a young and energetic officer from whom a faithful discharge of the responsible duties of the post may be confidently and safely expected. The step taken in raising the dues was wise. The sum of $20 as yearly dues is a bagatelle to any company, and with the funds at its disposal the Association can now print its proceedings, of which there has been no publication in book form since the Baltimore meeting of 1886. The burden of publication will perhaps not be so great when, as was suggested by Mr. Weeks, the Association, like the Telephone Association and other bodies of the same character, meets once a year, but even then the Association will have to incur other expenses, and will be at no anxiety in doing so with a full treasury.

The papers read at the convention were of the most varied character, bearing not only upon the direct electrical work in which the association as a practical body is interested, but embracing also a number of most valuable papers on points of the greatest importance to all interested in electric lighting. To begin with the non-electrical papers, that of Mr. Church on independent engines for incandescent light stations will probably be singled out as one exhibiting remarkable discernment and breadth of handling of the subject. Mr. Church has presented his side of the case in the very strongest way, and if experience and precedent go for anything there is no doubt that the practice which he there outlined regarding the subdivision of power for incandescent electric light stations is one which, already adapted to quite an extent, will be the standard of the future.

The immunity from a total breakdown, which a subdivision of power permits, together with the economy of fuel which high speed engines when worked at their full capacity show over those of slow speed when worked below their full rated power, makes the arrangement one of undoubted value. Mr. Church's paper showed that he was not in any way committed to the idea that power ought to be divided into small parts in every station, but, on the contrary, that this was a factor depending entirely upon the conditions under which the station operated. Thus, if the business of the station was sufficient to keep a 500 h. p. engine constantly at work, that was the smallest engine to employ in that station, and any additions thereto could be made up of similar or even larger sized engines if the station demanded such power. Altogether Mr. Church's paper is one which every one interested in commercial electric lighting would do well to study, but, as he points out, his reasoning applies more particularly to incandescent stations where the load is very variable and not to arc light stations which usually have very constant loads for the greater part of the run.

In somewhat close relation to this subject, the paper of Mr. Edson on steam pressure records is also worthy of attention, as the consumption of fuel in a central station may be dependent to a large extent upon the ability and watchfulness of the fireman, and a record of the steam pressure is probably as good an indication as can be obtained of the manner in which the furnace fires have been handled. Mr. Schieren's paper on belting also brought out many points very forcibly and usefully.

At recent meetings of the association, the electric motor has been to the front as an engrossing topic, but like everything else it is for the nonce overshadowed by the alternating current and its problems. For this reason, apparently, the paper of Dr. Liebig was not discussed as fully as the occasion warranted, and perhaps because the members are also invariably more interested in learning how to earn a handsome dividend than in mastering the mysteries of new formulæ; but still the motor was not neglected, and all accounts proved it to have arrived within a single year at the position of an indispensable adjunct of the older lighting industry.

Pittsburgh being the home of the alternating current distribution of this country, it was but natural that the system should have obtained considerable prominence as a subject of discussion before the convention, and those who went to Pittsburgh with the hope that the subject would crop up were not entirely disappointed. Besides the opportunity afforded for ocular demonstration of the nature of the system and the methods of manufacture employed, as exhibited in the works of the Westinghouse Electric Company, three of the papers before the convention brought out some very distinct facts with regard to the alternating current system. The first of these was an exceedingly interesting one by Mr. Philip Lange, who attempted to show that the present much discussed danger of watches becoming magnetized was not to be feared from the alternating current system so much as from the direct current, and, indeed, that the alternating current contained within itself all the elements sufficient to completely demagnetize a watch that had been magnetically affected. For this purpose Mr. Lange drew attention to the old experiment of placing a watch within a coil through which an alternating current is passed, and then gradually withdrawing it. We have no doubt but that a watch subjected to such treatment would be deprived of most of its magnetism. Reasoning from this standpoint Dr. Moses brought out a rather curious argument that, with these facts before us, the only current to be employed upon board ship, and whose action would not be felt by the compasses, is the alternating current. But the fact is, that even two direct current conductors when placed side by side or equi-distant from a compass needle have no influence upon it, and experiments actually made on board ship show that no variation of the compass is discernible under any condition of running with dynamos aboard. This is sufficient to allay any fears which may exist on that score; and other things being equal, it does not appear that the alternating current is better adapted for this particular purpose than the continuous.

The other papers, by Mr. Shallenberger and Mr. T. C. Smith, dealing with the subject, we reserve for discussion next week, when we hope to comment also upon the able papers with regard to underground work presented by Mr. W. W. Leggett and Mr. J. M. Smith, and that relating to insurance, of Mr. Barton. All of them are worthy careful perusal, and add greatly to the general fund of information.

* At the dates mentioned these were the largest numbers that had ever been published of any electrical periodical.

Seventh Meeting of the National Electric Light Association.

The seventh meeting of the National Electric Light Association was held on Feb. 21, 22 and 23, at the Monongahela House Pittsburgh, Pa. There were present:

BOSTON.—P. H. Alexander, G. W. Adams, S. E. Barton, L. W. Burnham, W. P. Clark, F. E. Clark, W. S. Clark, H. B. Cram, H. E. Duncan, G. W. Davenport, H. H. Eustis, J. N. Godfrey, A. V. Garratt, A. F. Mason, J. J. Pratt, F. Ridlon, F. R. Ross, C. D. Wainwright.
BROOKLYN.—E. F. Peck.
BALTIMORE.—F. R. Colvin, W. H. Harding, F. M. King, G. A. Liebig, J. F. Morrison, M. McCarty, A. Steuart.
BRIDGEPORT.—F. A. Mason, J. M. Orford, H. D. Stanley.
CHICAGO.—T. P. Bailey, S. S. Badger, J. L. Barclay, G. L. Beetle, W. L. Buckley, C. B. Curtis, F. E. Degenhardt, F. De Land, H. A. Glasier, F. W. Horne, M. A. Knapp, W. A. Kreidler, E. N. Lewis, W. H. Leonard, H. E. Longwell, W. H. McKinlock, E. L. Powers, J. H. Shay, C. D. Smith, E. A. Sperry, W. M. Talcott, F. S. Terry.
CLEVELAND.—W. H. Boulton, W. B. Cleveland, S. E. Cox, J. B. Crouse, C. C. Curtiss, M. A. Devitt, S. M. Hamill, W. C. Hayes, J. M. Hill, W. H. Lawrence, G. Miller, E. S. Sanderson, J. S. Scoville.
CEDAR RAPIDS.—W. J. Greene.
COUNCIL BLUFFS.—T. Officer.
CITY OF MEXICO.—J. P. Smith.
CHATTANOOGA.—G. C. Steward.
DETROIT.—W. A. Jackson, J. M. Smith.
ELIZABETH, N. J.—H. W. Pope.
FREMONT.—W. R. Caulkins.
FT. WAYNE.—R. Mackie, W. B. McDonald, R. T. McDonald, M. W. Simons, M. M. M. Slattery, G. A. Wilbur.
HARTFORD.—M. E. Baird, J. A. Dalzell, C. E. Dustin, A. D. Newton.
ITHACA.—E. L. Nichols.
INDIANAPOLIS.—B. Rorison.
JANESVILLE.—P. Norcross.
KANSAS CITY.—E. R. Weeks.
LONDON, ENG.—G. Forbes.
LYNN.—E. W. Rice, Jr., A. L. Rohrer.
MONTPELIER, VT.—E. S. Blackwell.
MINNEAPOLIS, MINN.—S. L. Leonard.
MENDOTA, ILL.—L. R. Curtiss.
MONTREAL, QUE.—W. R. Kimball.
NORKFOLK, VA.—Jas. L. Belote.
NEW YORK.—P. C. Ackerman, C. H. Barney, A. W. Butterworth, A. Conkling, F. G. Cartwright, W. L. Candee, W. F. Cullen, W. M. Callender, Isaac H. Davis, J. B. Edson, W. A. Giles, C. I. Hague, R. S. Hubbell, H. McL. Harding, F. E. Kinsman, G. W. LaRue, H. F. Lufkin, E. T. Lynch, Jr., Theo. Larbig, J. P. McQuaide, T. J. McTighe, F. A. Magee, G. T. Manson, T. C. Martin, Dr. O. A. Moses, E. S. Perot, G. M. Phelps, Jr., A. H. Patterson, C. W. Price, R. W. Ryan, F. G. Stone, C. E. Stump, C. A. Schieren, W. F. Swift, Jos. Wetzler, G. L. Wiley.
NASHVILLE, TENN.—Jos. Wills.
NEW HAVEN, CONN.—T. L. Bigelow, S. J. Fox, W. M. Frisbie, C. D. Warner.
NEWARK, N. J.—C. O. Baker, Jr.
NASHUA, N. H.—W. W. Caldwell.
N. ATTLEBORO, MASS.—L. M. Dillon.
OMAHA, NEB.—Minot Sewell.
PITTSBURGH, PA.—Arthur H Allen, E. G. Acheson, G. H. Baxter, N. H. Byam, H. M. Byllesby, W. L. Church, S. A. Duncan, J. H. Gates, C. Gormley, W. C. Kerr. H. Metzger, J. W. Marsh, — McElroy, G. Pantaleoni, Geo. F. Porter, O. B. Shallenberger, F. S. Smith, T. Carpenter Smith
PHILADELPHIA, PA.—David Brooks, A. J. DeCamp, N. H. Edgerton, Geo. Guilliam, M. D. Law, Alf. F. Moore, Jas. A. Pentz, Anthony Reckenzaun.
PEORIA, ILL.—Lafayette Cole.
PLAINFIELD, N. J.—W. H. Moore.
PETERSBURG, ILL.—C. D. Wright.
ROCHESTER, N. Y.—Geo. A. Redman.
ST. LOUIS, MO.—G. W. Parker, D. R. Russell, J. A. J. Shultz.
SAN FRANCISCO, CAL.—S. H. Taylor, F. Butterworth.
SCHENECTADY, N. Y.—A. T. Moore.
SPRINGFIELD, MASS.—A. P. Wright.
TRENTON, N. J.—W. E. Frick.
UTICA, N. Y.—Jos. C. De Long.
WASHINGTON, D. C.—Fred. W. Royce.
WELLSVILLE, O.—H. H. Whitacre.
WILLIAMSPORT, PA.—Frank Wyckoff.

The first session began at noon on Tuesday, the 21st, when the convention was called to order by President J. Frank Morrison, who said:

PRESIDENT'S ADDRESS.

Gentlemen of the Convention:

When the National Electric Light Association, in its wisdom decreed that its next meeting should be held in this city, it was certainly an evidence of our faith in the stability of the business in which we are engaged.

The cheapest of coal, the natural gas, every element that nature could furnish for illuminating purposes, are here spread out freely without money and without price.

To face these existing conditions, the electric light, which is comparatively expensive, must have behind it the backing of nerve and courage and an unbounded faith in the good taste of the people of Pittsburgh, who, with its greater cost, have adopted it in preference to that of its mighty competitors; that light which not only illuminates but adorns their dwellings, their mercantile houses and their public buildings.

Seven years ago the first electric lighting company was started in Pittsburgh with 14 arc lights. It struggled along against the prejudice, against time-honored usages, for six years, at which time 300 lights were burning where there had been one. Here a new era opened, and within the short space of 18 months the electric lighting business increased to 350 arc, and 20,000 incandescent lights, which now blaze in a constellation of glory reflecting credit upon its progenitors. During the past six months we find that great progress has been made in cheapening the methods by which electric lighting is produced. This is noticeably the case in the arc lighting business.

The extension of arc lighting since our last meeting has been something marvelous, while even that has been outstripped by incandescent lighting, both by direct and alternating systems.

There are to-day, in this country at least, 3,000 isolated arc or incandescent plants and over 1,000 central stations. At our last annual meeting there were in operation in the United States, approximately, 125,000 arc lights. Since that time there have been installed and contracted for probably 50,000, bringing the present actual total within the neighborhood of 175,000 arc lights.

The number of incandescent lights at our last meeting was slightly over a million and a quarter. The installations and contracts made since that time are reported to foot up nearly half a million, bringing the present total to about 1,750,000, giving, it will be noticed, on the whole business a proportion of 10 incandescent to 1 arc. These are statistics which exhibit extraordinary growth and yet are conservatively estimated.

I beg again to urge upon the members of this association, the necessity of intelligent and well directed efforts toward the more perfect construction of lines and installation of apparatus. While some fatal accidents have marred the record of the past six months, I am glad to say that they have been fewer in number and less chargeable to the danger of the system itself than have been similar casualties in any other calling that involves the use of power-driven machinery.

The attendance at this meeting is sufficient evidence of the success of this association. The Secretary's report shows a membership of 168. By reference to the report of the Treasurer we find that a fairly good financial showing is made.

With a debt of only $98 and with $971 in the treasury to cover all expenses of the present fiscal year, we need have no fears on that score.

Considerable progress has been made by Arthur Steuart, Chairman of the Legal Committee, toward bettering our condition in the Patent Office. This is a matter to which your attention will be strongly directed during the present convention, and I ask for it your calm and careful consideration. You will be called upon to decide whether or not further steps shall be taken in the direction already pursued. I am seriously of the opinion that for the better protection of those in the electric lighting field whose first investments depend largely upon the validity of their patents we should, if it is possible to do so, prosecute to a successful conclusion a work so well begun by the Legal Committee.

Papers will be read as follows, on "The Practical Side of the Distribution of Alternating Currents from Central Stations," Mr. T. C. Smith, Pittsburgh; on "Underground Conduits for Arc Light Wires," Mr. W. W. Leggett and Mr. Jesse M. Smith, Detroit; on "Electric Motors," Dr. G. A. Liebig Baltimore; on "The Economic Value of Steam Pressure Records," Jarvis B. Edson, M. E., New York: on "Leather Belting, its Origin and Progress," Mr. Charles A. Schieren, New York; on "Independent Engines in Incandescent Light Stations," Mr. W. Lee Church, Pittsburgh; on "How Can We Protect our Watches from Magnetic Influences?" Dr. Philip Lange, Pittsburgh.

Permit me to congratulate the association upon the excellent work done by Mr. Duncan, Chairman of the Executive Committee, who has been so ably assisted by his colleagues, and who has shown his signal executive capacity by the excellent manner in which he has prepared for the prompt transaction of the business of the association, and for the comforts of its members.

I desire to call your attention to one or two points which reflect a great deal of credit upon the citizens of our own country, and perhaps, to put it mildly, negligence on the part of those abroad. Statistics show that in this country we have 175,000 arc lamps in service and also a large number of incandescent lights. Now the question naturally arises, why should we have made such headway on this side of the Atlantic and why should the business have been practically at a standstill on the other side. The answer may be given in two words, vicious legislation. If one absolutely inimical to progress had planned out an act of Parliament which would have absolutely quenched electric lights in Great Britain and Europe he could not have better succeeded than those who framed that infamous act known as the Electric Lighting Act, which has paralyzed that industry, has smothered invention in that direction, and which finds expression in the spleen which casts slurs upon those of us on this side of the Atlantic who have been diligently engaged in procuring this light which has been so popular amongst all classes of our people. A few years ago it was only the rich who could enjoy this luxury. To-day, it is brought to the door of the poor man's house and within a year or two more it will be the popular light which will not only take the place of the illumination by gas, but will take the place of the coal oil lamp, and will be within the reach of every one who is capable of reading, and who is desirous of using the electric light for that or any other purpose.

The PRESIDENT then introduced Major W. C. Moreland, who on behalf of the Mayor welcomed the convention to Pittsburgh. During the course of his remarks, Major Moreland referred to his own work in telegraphy 40 years ago under the guidance of Mr. David Brooks.

The PRESIDENT then declared the convention open for the transaction of business.

The Secretary read a letter from Mr. Geo. S. Bowen expressing his regret at being unable to attend the convention; also a letter from Mr. F. C. Osborn, Chairman of the Committee on Progress of the Engineers' Society of Western Pennsylvania, inviting the members of the Association to attend a meeting of that society at 8 o'clock in the evening.

On motion of Mr. Duncan the invitation was accepted.

Mr. DUNCAN also moved that an invitation be extended to the Engineers' Society of Western Pennsylvania to attend the sessions of the Convention, which was adopted.

A letter was read from the Allegheny County Light Company inviting the members to visit the station of that company. Accepted.

A telegram was read from Mr. H. C. Davis, President of the Electric Club of New York, tendering to the Association the courtesies of the Club House in the event of their holding the next convention in the City of New York. On motion of Mr. DeCamp the communication was referred to the committee to be appointed to name the place for the next meeting of the association.

A letter was read, signed by the various Westinghouse head companies, inclosing a contribution by those companies of $1,150, "to encourage the best interests of the association." The communication was, on motion, accepted with the thanks of the convention.

The secretary read his report, which on motion was accepted.

The report of the treasurer was read and accepted.

The report of the chairman of the Executive Committee was read by Mr. Duncan.

On motion of Mr. H. W. Pope the action of the Executive Committee was approved.

The recommendation of the Executive Committee that delinquent members shall be notified at once that they are in arrears and that they will be dropped from the rolls after the expiration of thirty days if their dues are not paid, was, on motion, adopted.

Mr. DUNCAN here submitted the following amendment to Article 8 of the Constitution: "That the yearly dues of the Association shall be $30." This was laid over for one day according to the rules.

The PRESIDENT appointed as the committee on this amendment Mr. Duncan, Dr. Moses and Mr. Weeks.

Mr. DUNCAN: I desire to make the following motion, which was unanimously recommended by the Executive Committee: That Prof. George Forbes, of London, England, be elected an honorary member of this Association. The motion was carried.

Mr. LYNCH: I move for the appointment of a committee of five for the nomination of officers for the ensuing year, said committee to also make a recommendation to the Association for the next place of meeting, the committee to be appointed by the Chair. The motion was carried.

The report of the Committee on the Insulation of Wires and Construction of Plant was read by the secretary.

A paper upon the same subject by Prof. Elihu Thomson was then read by Mr. Rice.

INSULATION AND INSTALLATION OF WIRES AND CONSTRUCTION OF PLANT.

I have been requested to present my views on the above subject, and having recklessly allowed myself in spite of the many other demands upon my time to accept the chairmanship of your committee on the same subject, I have felt it my duty to at least say enough to provoke a general discussion and interchange of views between others who may have given more special study to the matters in hand. My endeavor therefore will not be to arbitrarily lay down any rules, but rather to point out directions in which information may be gained and improvements made.

The subject is certainly very extensive in its scope, and could not be dealt with except in a very superficial way in the time at our command, and meanwhile I feel constrained to state that I make no claim to the possession of any of the qualifications which would be requisite for thorough work on the subject.

In the installation of electric light or power plant, we first of all find that the conditions vary very widely. Its size, locations, the distance covered, or length of circuits, and the climatic effects met with, need to be considered.

Then, again, the nature of the plant itself, whether arc light, direct incandescent, alternating system with transformers or converters, etc., governs to a large extent the conditions of the installation of the wires and of the plant itself. We may, of course, find in a single station or installation representations of these and other characters of plant, such as medium potential circuits for power transmission alone.

Three or four years ago we should have been required only to take into account simple cases of high potential for arc circuits and low potential direct currents for incandescent multiple arc circuits, but the range now covered may be considered to be from any potential above 50 volts up to several thousands and any current strength from about one ampère up to several thousand ampères.

In considering the proper insulation and installing of wires for conveying these potentials and currents, we are required to still further extend our field of view and divide them into aerial or overhead wires or conductors and underground systems, and each of these taken in connection with the conductors for indoor distribution to the lamps, motors or other energy uses. We have thus outlined the field which should be covered in dealing with a subject such as we have before us. Insulation and installation of wires and construction of plant would furnish as a subject material to fill a many-paged volume and not by any means exhaust it. May such a work soon be forthcoming.

Concerning the relative merits of overhead conductors and underground conductors, it is pretty generally agreed that, except for the expense and the difficulties of insulation and connections from the mains, the underground system would be preferable as avoiding unsightliness and liability of interference either by leakage, induction or contacts with the overhead wires. Now, to preserve insulation of the lines conveying high potentials, which potentials cannot be avoided if distance is to be covered without conductors of such size as to have a prohibitive cost, is a vital question. It may well be conceded that when the potentials are very low, say 100 to 200 volts, the difficulties of insulation are very slight as compared with those of the use of two or three thousand volts.

It is a notable fact that so far as concerns the placing of overhead wires, particularly the wires of telegraph, telephone and other such systems, and in some cases of electric light wires, extreme disregard of systems or orderly direction for such wires is the cause of much of the unsightly appearance presented by them, and much of the liability to get out of order. The tendency also is to use very light and easily broken wires for telephonic work, such as may at any time come down upon the necessarily stronger electric light wires, strength being synonymous with efficiency in these latter.

It is thought that there is need of some rules or enactments to render impossible the mazes of telegraph, telephone, private wires, fire alarms, live wires, dead wires, and electric light wires (which for our purposes may be considered very live wires) such as may be seen in many of our large cities.

Should the wires of all kinds be laid or hung in orderly bundles having a definite direction, and only changing that direction by definite angles, such as right angles, in accordance with a pre-arranged system, I think that much of the objection now existing to the placing of overhead conductors could be eliminated. Add to this a requirement increasing the durability and tenacity demanded for telephone and telegraph wires, and their supports and the dangers of leaks and grounds would in a large measure be removed.

Many trials have been made, and considerable progress has resulted therefrom in the direction of securing an insulating covering for electric wires as may adapt them to the use of high potentials without leakage and prevent contacts forming by abrasion with other wires. This appears to be one of the most difficult problems in electric engineering. The problem is not so much to find a first-class insulating substance for wire covering, but to find combined therewith or to combine therewith the qualities of indefinite durability where exposed to the weather, and great toughness and power of resisting cutting or abrasion. For overhead work not only is an excellent insulator capable of withstanding very high potentials without leakage or rupture required, but such property must be retained along with the mechanical properties of hardness and toughness for indefinite periods. Besides, the cost must not be too great.

To what extent any quality of insulated wire or insulating material for outdoor use fulfills this requirement is a matter which it is difficult, indeed, to determine fully, particularly as a test for durability must necessarily require a long time to complete. Indeed, it would seem that our best guide must be the experience gained in the use of different wires on a large scale under different climatic conditions and without extremes of heat and cold more or less great.

Aside from the insulation given to the wire by its covering, considered purely as an insulator, most stress must be laid upon the requirement of resistance to mechanical friction or abrasion, as tending to give immunity from grounds by contact with other wires or with tree-branches, roofs, cornices, etc.

Toughness and elasticity of the insulation are hence seen to be qualities of high importance.

Whether such mechanical tests as will represent the conditions of actual practice in the use of the wire in relation to abrasion and percussion, bending, etc., which may break through the coating of insulation, can be devised and applied to test wires is somewhat doubtful, though without doubt much information may be obtained in the pursuance of such an object.

The retention of the toughness and elasticity for a reasonable period is of course demanded, and it is this retention which in otherwise excellent coverings is often absent, the effect of exposure being to render the materials brittle and porous.

It has often been proposed to make tests for the insulation resistance of the coverings of certain lengths of any wire, taken as examples representing an average for such wires, under potentials somewhat exceeding that existing under actual use or practice, and so to determine the insulating capabilities of different coverings, but it is my opinion that such tests are certainly useful and important, and, in the case of underground wires and cables, indispensable; yet, for overhead work, since most of the length of the wire is exposed to air only, which is a practically perfect insulator, and since the chance of leakage from the lines arises most from imperfectly insulating supports and from accidental contacts with other wires or surfaces, additional tests would in any case be required to determine the suitability of an insulator for overhead lines. In this connection it may be stated that during thunder storms, overhead wires are subjected to violent inductional effects, giving rise oftentimes to the momentary charging of the lines with potentials very far in excess of the potentials of any demands, and capable of breaking through the wire covering where it may be near or touch a metal object or wet surface. This breaking through may give rise to a weak spot which will be followed by the dynamo's current itself, if of high potential, and if at the same time other conditions be favorable to a diversion of current.

When overhead wires or pole lines are required to pass through and between branches of trees, a condition not infrequent in many of our towns and cities, considerable difficulty may be found in preserving the insulation of the line, the covering of which is apt to be rubbed off by the tree branches swaying in the wind. Fastening insulators to the branches for support and attachment of the wires is an uncertain remedy, on account of the swaying of the tree taking place in different directions not transverse to the line of wire, so that the wire is strained or detached from its support along with the insulator by the violence of the actions. Many and ingenious are the devices which the over zealous lineman makes use of to suddenly or gradually and mysteriously lop off the offending limb, when the case is exceptionally critical and permission for the amputation of the offending member cannot be obtained from the conservative citizen whose sidewalk supports the obstacle to the lineman's ambitions.

It is also customary to thicken the insulation of the wire at such places as are threatened by abrasion by winding on it a wide band of tough and adhesive tape, such as can now be found in the market. If neatly and thoroughly done, the insulation of the wire may thus often be preserved under decidedly adverse conditions.

It must be admitted that the insulation of a high potential circuit can never be too good, and that therefore any measure which may tend to its improvement and preservation is a double advantage, for not only are the dangers of grounds and leaks lessened, but the power of the current to do useful work is assisted. A considerable leakage from a high potential circuit means, indeed, a loss of power or efficiency of the system. For instance, the loss of one-half an ampère of current at a potential at 1,500 volts, would represent about one horse-power of current energy lost, costing more than a horse-power at the dynamo pulley to supply such a leak.

This latter consideration is of especial importance in dealing with the lines feeding transformers with alternating currents at high potentials.

With 1,000 volts in the primary circuit it is readily seen that a badly constructed or leakage line might easily cause the loss of a considerable percentage of current, such as would reduce the economy of the system, more particularly when running under light loads, at which time it is desirable to secure and to keep up the best possible efficiency.

When wires or cables are to be laid underground their resistance to abrasion is of importance only when they require to be drawn into conduits or sections of conduits, but when once placed intact, they are not necessarily further subject to mechanical injury, as they are generally surrounded by protective casings or tubes.

The total exclusion of moisture and the possession by the wire coverings of a high insulation resistance are requisites of great importance in such work. The difficulties are with low potentials comparatively easy to provide against, but in the case of wires at high electric potentials or pressures, such as arc light or alternating current primary lines, such difficulties are much exaggerated.

The least access of moisture, such as may occur by flaws in the insulation, may result in the production of a bad ground, or a slight leak, due to some original defect, may so improve itself by the passage of current as to become a bad fault or a complete connection to earth. It would seem best in all cases not to place reliance upon the integrity and perfection of but a single insulating coating or covering for the wire, but to give to it, say, three coatings, successively applied, and which are, in a measure, independent coverings, all of them impervious to moisture and good insulators.

If composed of different materials, the peculiar liabilities to defect of one such coating may possibly be compensated by other qualities in another coating, so that there may be small chance of superposed defects in all coatings alike.

Let but the insulating capacity of each layer or coating be amply good to withstand the potential used, and it is difficult to conceive how trouble could arise from leaks due to defective portions of the covering. First cost is, however, a barrier to the perfection of underground systems, to save which cost less effective and cheaper structures are often given the place which should be occupied by the more perfect and the more costly.

It is important that, in cases in which overhead wires or wires above ground are connected with underground lines, efficient means for carrying inductive discharges to earth be provided, such as is secured by the use of proper lightning arresters; for faults may otherwise be produced in the best underground system of conductors due to static inductional discharges existing during thunderstorms, at the moments of lightning discharge. These discharges are in overhead lines oft-times quite vigorous, and capable of puncturing moderate thicknesses of insulation. They are not to be confounded with actual passage of lightning strokes to the lines, which, of course, have an infinitely greater capacity for mischief.

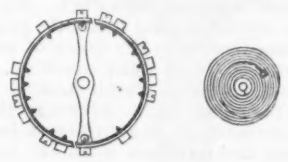
The preservation of the insulation of *inside* wiring is not difficult where the potentials used are low, nor is it difficult with due exercise of care and skill in the running of the wires and the selection of suitable courses for them to take, to install simple series lines, such as those for arc lights, which shall be practically exempt from leakage, unless abraded and brought into contact with conducting objects or moist surfaces involving leak to earth.

Unfortunately, owing to lack of skill and judgment and haste in installing, much of the wiring done is not as well done as it should be for the best results.

Distribution of current to groups of incandescent lights upon arc light or other high potential lines should always be undertaken with great care, and it is thought that such work should only be undertaken when exceptionally favorable conditions for avoiding accidental leakages exist, especially should the potential of the line at the dynamo exceed 1,500 volts, or an amount which would sustain thirty arc lamps in series. One of the important elements of safety in such installations is simplicity and ease of inspection of the wiring, and no concealed wires should be used in them.

Concerning the wires which are suitable for indoor work and particularly for high potentials, the endeavor has been to combine moisture proof and fire resisting, or rather incombustible materials in the covering. The difficulty has been to find moisture resisting substances which would not carry fire, and fire resisting or incombustible material which would not carry or absorb moisture. The two properties seem in most cases incompatible. The tendency now is to surround the wire with a first covering of moisture proof material of the nature of rubber, bitumen, resins, etc., and outside of this to place a second layer which will not carry fire.

For house to house and general incandescent lighting, where the distances from the station are not too great, the



PALLADIUM NON-MAGNETIC COMPENSATING BALANCE AND HAIRSPRING.

direct low potential system possess most of the advantages, the difficulties of leakage from the defective insulation being of course at a minimum, but where the distances are so great as to make the required outlay for copper in the conductors practically prohibit the extension of the system, a transformer or converter system, if of good design and economy, may be made to yield excellent results. In such cases the high potential primary wires need not enter the building, or when they do may be suitably protected, the house or inside lines being of such low potentials as to be run with ordinary precautions as to leakage. However, the integrity of the system would be changed should a connection or leak form between the primary and secondary wires of the transformer, thus connecting the local or house line with the high potential outside mains. Such a connection might easily exist unsuspected, and would be a constant source of menace or possible danger, not discoverable by the mere tests for grounds as applied to the primary line at the station.

The expedient of securely grounding the secondary or local lines was devised by me to overcome this difficulty. It insures immunity from the risks arising out of possible leak from the primary lines to the house lines, because such leaks are at once detected by the ordinary tests for grounds.

The consideration of the subject of what appliances are the best for the detection and location of leaks or faults in the insulation of conductors when they exist and whether the ordinary crude methods are adapted to all cases by such detection, would prolong the present paper much beyond its intended limits and it will have secured its object if it open up an opportunity or give occasion for a free consideration in the interchange of experience and ideas upon the general subject forming its title.

Dr. MOSES, in the discussion of this paper, urged the continuance of the committee.

Mr. DE CAMP agreed with Dr. Moses in thinking that that committee should be continued. There was a great deal for discussion in the report which should be brought out in the course of some paper which could be presented to the association before the close of the meeting which the members of the committee would have the benefit of. He also moved that the committee be continued as it is, to report at the next meeting of the association. The motion was carried.

Mr. LEGGETT: I wish to make simply a suggestion which occurred to me as this paper was read. That is, the effect upon a lead covered cable of a short kink or of a dent in the lead; the compression of the insulation whereby the insulation is rendered a better conductor, and so that at that point there is a better opportunity for the current to leak out.

Mr. RICE, in answer to Mr. Leggett's inquiry, stated that the insulator has to stand on a 1,000-volt alternating circuit over1,000 volts that is, more than it would be on a direct current. That is occasioned by the wave going up to nearly 2,000 volts and then going down to zero.

Dr. MOSES and Mr. De Camp spoke on this subject, but the president reminded the association of the fact that the discussion would be more appropriate to a paper prepared by Mr. Shallenberger, entitled "The Energy of Alternating Currents," to be read later.

Mr. EUSTIS: With regard to underground wires, I wish to mention a little result that came to my notice some time since which may be of some use to the convention. In Professor Thomson's paper he states that after the cables are once laid they are then not liable to be disturbed, owing to the mechanical covering outside. But I know of one particular case in which the insulating wires were laid in a conduit under a railroad track, in a box about six inches square. Three or four wires were laid in loosely. Every time it rained, the water from the side of the tracks washed more or less through this conduit, and carried with it, I presume, some sand. At all events, after the wires had been laid about two years the insulation was found to be destroyed; and on drawing the cables out it was found to be due almost entirely, as far as outside appearances went, to purely mechanical injury. The only explanation that I can see for that was the fact that as the heavy trains went over this conduit they compressed the ground, and the cables being laid, as they were, suspended, owing to their own stiffness, the two wires slipped by each other and gradually chafed the face of the two wires, one upon the other, and cut the insulation through. If any one has had a similar experience I think it would be a benefit to the association if he would state it.

In reply to a question from Dr. Moses, Mr. Eustis stated that the wires were drawn into the box loosely, and they were undoubtedly full of kinks. His idea is that as the box gave from the weight of the trains, the wires being loose in the box, because of their own stiffness, would spring against one another, the two wires bending differently.

Mr. DAVID BROOKS: This slight jar or concussion can only be seen after a time. This matter was brought to my notice the other day by the Pennsylvania Railroad Company. They had laid three cables in a wooden box along their railroad track. The boxes are four inches square and are fastened or closed; but it was found after a while that the cables began to give way. They opened the boxes and found that where they were laid on the bottom board of the box the cables had, by reason of this jar, worked about half way through the board, and it had, greatly to their surprise, taken the covering off, so that the insulation was ruptured. I have heard that in London, where they run the pipes on the overhead ways, even of those made of bricks or of solid masonry, this continued jar will, in time, begin to affect them. So that it is well when anything of that kind is laid to have it away from anything like concussion, although the concussion may be but small in amount.

Mr. E. B. SUNNY: I would like to state, in reply to Mr. Leggett's question as to the effect of a dent in a lead cable, what the effects are upon insulation. We have to-day a large number of burn-outs in our lead covered cables, and I have been investigating a few of them, and I find, as a rule, that the cable has burned out at a point where the surface was perfectly true, and where there were no indications of mechanical injury. On the other hand, in pulling out cables which have been destroyed we have found portions of them where the mechanical injuries have been so great as to completely clean the lead off of the insulation, leaving the wire bared. There was no indication at the point where the lead was bared off that any leak of the current occurred at that point.

The following paper by Dr. P. Lange was then read by Mr. T. C. Martin:

HOW CAN WE PROTECT OUR WATCHES AGAINST THE INFLUENCE OF MAGNETISM?

I have been invited to deliver to this convention an address on the influence of electric currents upon small magnetic matter. I can comply with this request in no better way, perhaps, than to devote myself especially to the discussion of this most subtle influence as applied in particular to the delicate mechanism of our watches. Every man among us has doubtless been often impressed with the idea that absolute accuracy is the most desirable quality a time-piece can possess; that reliability is most essential to render efficient a guide so frequently consulted as the watch. You will therefore acknowledge the real importance of the question as to how we can best protect our time-pieces from the influences of a magnetism that must render them inaccurate and unreliable. Since the introduction of powerful dynamos has taken place in large electrical establishments, and in the many buildings supplied with independent and separate lighting plants, it has become evident that the watches carried by persons coming in proximity to the dynamos (whether such persons be constantly employed near the dynamos, or only visitors to the works, it matters not) are very likely to become magnetized. Once under the influence of magnetism, the time-pieces must very soon show the effects of it, by either losing or gaining time, or stopping altogether; and the cause thereof is such, from its very nature, as would be liable to puzzle an expert watch maker to remove. The advent of electricity in its modern and manifold branches of utility has forced upon us the importance of this question: How can we prevent this magnetism from gaining a damaging influence upon our watches? or, if not prevented, how can we best and most speedily repair the damage done?

Let us not look upon the question lightly, but rather in all earnestness. Let us bear in mind that, while the powerful dynamo in the engine room, in the manufactory, the business house or the ocean steamship sends forth its currents through many lines to furnish light or power, it sends forth also a very different influence, and one that makes mischief with the watch carried by the engineer or electrician, the visitor to the works, or the captain, or the pilot who may happen to approach for a moment within the influence of such a dynamo. Let us not forget that, in the latter event, serious results may follow, for, by the captain's chronometer, in conjunction with the compass, the great ship is sailed. We should bear in mind that, in the manufacture of our best watches, the object of the maker is to confine in the smallest space possible the greatest strength and durability. In order to accomplish this object, he finds it necessary to use, for the principal parts of the watch, hardened steel, a material decidedly susceptible to the influences of magnetism. The hair spring and the balance wheel—vital parts of the watch—are thus frequently constructed; and even though the balance be

made of a combination of metals, the steel in the little points on the wheel may be attracted to the little steel screws necessary to perfect firmness in the larger mechanism of the watch, for these screws may be readily charged with magnetism of sufficient force to be long retained and to exert a continual influence over the other magnetic matter. This escapement wheel, likewise of steel if duribility be desired, becomes easily magnetized also, and its movement is seriously retarded. Then the hair-spring, with its delicate coils close together, may be so polarized that the coils on the side next to the nearest steel screw will all adhere to each other and play havoc with the motion of the watch.

Thus our very best time-pieces are most susceptible to the influence, which may, and often does, retard them to the extent of several hours a day.

In my work as an investigator of this subject, which has extended over a period of several months, I have formed three separate solutions of the problem: First, to have the watch made of material that cannot be magnetized; second, to inclose the works in an iron case, so as to shield the vital parts of the watch, and third, to apply efficient means to demagnetize the watch that has not been favored with the safeguards.

With regard to the first solution, I have had occasion to experimentally test its efficiency. I have applied the most complete magnetic tests to watches made by a well known watch company, which were claimed to be perfectly free from all magnetic influences. The hair spring and balance wheel of these watches are made of palladium. I have no hesitation in saying, after subjecting these watches to the strongest magnetic influences in the Westinghouse electric works, that their claim to recognition as non-magnetic time-pieces is fully sustained. I have had one of these watches perfectly timed to run with another, and subjected the two to opposite extremes as regards magnetism, yet discovered no deviation in their time-keeping. The one was wholly free from the magnetic influence; the other was running at a point between the pole pieces of a most powerful magnet. I have watched both of them closely for weeks, without being able to detect any difference in their time.

Taking the hair spring and balance wheel from a watch, I have placed them upon a little cork float in the water, and then approached them with a most powerful magnet, without being able to detect the slightest motion of the little float or its burden; whereas the ordinary steel hair spring and balance wheel, subjected to a similar test, were so strongly attracted that they not only moved the cork float but jumped from it to the magnet instantly.

While it is true that the screws and a large portion of the other mechanism in these watches are made of steel, yet all the delicate movements in the work are so entirely non-magnetic that, although the steel parts should be charged with magnetism to the highest degree, there would be no perceptible effect exerted upon the running of the watch.

Concerning the second solution of the problem, that is, shielding a steel watch against magnetic influences by inclosing it in an iron case, I would say that I have not personally experimented with this; but acquaintances of mine, entirely competent to do so, have given me an excellent idea as to what such watches are capable of. Watches, in such cases, have been very successful in resisting the ordinary influences of the dynamo rooms. But I would not advise that they be exposed to the influence of very strong fields, because, in that case, they would be magnetized and lose time.

Now, for the third solution of the problem. Since it is true that comparatively few non-magnetic watches are in use, and that there are a great many of the ordinary watches with steel works, the question comes up, naturally: How can we best demagnetize the watches if they have become injuriously magnetized?

An old way of doing this was in placing the magnetized time-piece in close proximity to a dynamo, then revolving the watch rapidly by means of some mechanism and slowly removing it from the magnetic influence. This is a very unreliable cure at best, and, in many instances, quite ineffective. A much better method has presented itself to me. I had occasion, recently, while constructing instruments for the alternating current, to observe some facts in connection with this kind of current and its peculiarities, which were suggested to me as being entirely available for use in the process of demagnetizing watches. In sending an alternating current through a solenoid, without breaking the circuit in the latter, I found that the steel core had lost its magnetism entirely. Magnetizing the core as strongly as I might before this operation, it would be, as I discovered, entirely demagnetized after submission to the process described. Then I found the same proposition to be equally true as applied to a whole handful of steel particles. They might adhere to each other ever so strongly before the operation; but if I endeavored to pick one of them out of the solenoid with the circuit undisturbed, the steel particle would come out entirely alone, wholly demagnetized and free from attraction to the others. Then I tried a watch whose steel pieces were thoroughly charged with magnetism, and I found that the same process exerted the same effect upon the watch as upon the steel core or upon the many particles of adhering steel. It was utterly demagnetized in all its parts, perfectly cured of its magnetic ailment. It would be unsafe to bring such a perfectly restored watch within the influence of magnetism, unless the owner should be desirous of again resorting to the still reliable process described. The solenoid need not be described to electricians. It is a very simple contrivance filled almost to the top with soft iron wire, leaving just room enough at the top, if designed for the purpose described, to allow the insertion and removal of the watch in the manner noted. Any person can apply the test successfuly, and, if it be in a jeweler's store or any other place lighted by incandescent lamps supplied for alternating current, the person need only remove the lamp from its socket, insert an attachment plug in its stead, connecting the current with such a solenoid, dip the watch in the hollow end of the solenoid, and, after leaving it in there awhile, remove it without disturbing the circuit. In this way a perfect cure for magnetized watches might be applied in any store, factory, or other establishment having an alternating incandescent lighting plant. In conclusion, I have only to say that the first solution of the problem described above, namely, that of getting perfectly non-magnetic watches, is the best and safest one for those whose time-pieces are liable to be subjected to magnetic influences. I may also add that the third method or cure described demonstrates the wonderful resources of the alternating system of electricity, which, though it may work damage like other systems, has yet within its own qualities a perfect curative power, which cannot be claimed for the continuous or direct current.

DR. MOSES: The observations made by Mr. Lange in his paper more and more impress upon me the absolutely essential character of alternating currents for all distribution of electricity where we have to depend for life or the safety of property upon the compass needle. I think that that paper points to the abandonment of the continuous current distribution of electricity on board steamships. That is a very broad saying, but I think it will be proven or supported by the facts that he has mentioned, and that as soon as the attention of the owners of steamship lines is called to it they will investigate the matter and verify the statement by experiments, and that the result will be a change of the continuous current machines into machines producing alternating currents. That is a most important thing, and may be the means of saving many lives.

MR. SMITH: I would like to ask Dr. Moses what would be the effect upon the ship of de-magnetizing the compass. What mischief would it do.

DR. MOSES: The result would be that the ship would float around indefinitely; and when they were thinking that they were going to do the most they would find the needle following the movement of the ship, and going around as any needle would if you blow upon it.

MR. KERR: I might mention the fact that there are about eight needles in a large ship's compass, and it would be hard to demagnetize them all at once.

MR. LAW: I quite agreed with Mr. Lange in his experiments, and I may state that I have been considerably troubled with my watch. It has a shield on it, and I will guarantee that, if placed side by side with any watch in the room, it will interfere with that watch's movement. I mean any watch not properly protected. I have had considerable experience since the time of the Electrical Exhibition in Philadelphia. While there I had demagnetized hundreds of watches by the old process of spinning them between the poles of the dynamo. I went through that precise experiment last week with Prof. Houston, and the remarks which he made I wish to call to the attention of those who are investigating this subject. I will not state them in detail, but they refer to the old experiment of turning a copper disc between the poles of an electro-magnetic machine. That copper disc will produce currents which are created, I believe, in Barlow's wheel. The supposition was that, although the balance wheel of the watch was made of purely non-magnetic material, still, if placed between the poles of the dynamo, its influence would affect the balance wheel the same as it did in Barlow's wheel. The first experiment was to place the watch in the safe at the works for three weeks. It was a watch manufactured by one of our largest watchmaking concerns in the country, and it was purely non-magnetic. The action was perfect. It was timed every day by a reputable watchmaker. This watch was placed on the poles of a 20-light Weston machine, and remained there for five minutes without any effect. My own watch was placed by the side of it, and instantly stopped. Then the watch was placed between the poles of an Arnoux-Hochhausen dynamo—a thirty-light machine. The armature was taken out, and the watch braced up by wooden blocks, so as to come right between the poles of the magnet, and directly in the strongest line of the field of force. We put that dynamo in an arc circuit; the watch was placed in and allowed to remain there one hour. It lost fifteen seconds during the time. But understand, gentlemen, that the influence of the dynamo in this case was far more powerful than it would ever be called upon to sustain in ordinary use. I wish to call attention to those experimenting in that direction with a view of ascertaining if they have discovered any action on the balance wheel, even though it be non-magnetic, upon this old principle of Barlow's.

MR. A. V. GARRATT: I confess that Dr. Moses has somewhat frightened me, but I am informed by a friend, an engineer of experience, and in whom I have confidence, that in some of the great ships which are covered with a perfect ramification of wires, there has never been found any influence whatever exerted upon the compasses by the electric plant which lights the ship, and does a part of the mechanical work upon it. In saying that, I do not wish in any way to reflect upon what Dr. Moses says in regard to the value of using alternating currents where they can be so used on board ship, or in other places where we must rely upon the magnetic needle; but it does not seem to me wise that it should go out of this convention that the present apparatus in use upon steamships is one of very great danger. On board the U. S. S. "Trenton" the curves of that ship and its magnet were worked out almost every day for a time after the electrical appliances were put on board, but no variation of the compass needle, or of the magnetism of the ship itself, or of any part of it, resulted, so far as the engineers, who very carefully investigated the matter, were able to discover, resulting from the dynamo plant which the ship carried.

MR. SPERRY: I would like to ask the last speaker if it is not a fact that those compasses are provided with heavy masses of metal, thus forming a magnetic shield around the compass.

MR. COLVIN: On most ships the compasses are surrounded by a mass of metal which acts as a shield. In the case of the "Trenton" (and I was aboard of her for some period) I had occasion to work those deviations of the compass, and they were worked out on this side, as well as in the Mediterranean. We would swing ship and take the bearing of the sun on every point, and every half point sometimes, with the dynamo going, and then with the dynamo not going; with certain lights in and certain lights out; with lights going in the pilot house, and lights not going in the pilot house. We had a torpedo apparatus there, of which I had charge, and the currents of that did not affect the compass at all. The ship's compass is composed of a number of needles of steel on the underside of the spar deck; and I never knew any variation in those curves that would amount to anything. The captain of the ship does not walk about the ship not knowing what his compass is doing. He knows more about that compass than he does of his own mind, and it is worked out every morning; and every morning the captain takes a sight for the longitude, and by that corrects any deviation of the compass, and so he is pretty safe.

DR. MOSES: I would like to ask Mr. Colvin if a wire carrying the entire current from the dynamo that was competent to supply five hundred 16-candle Edison lamps were brought near to any one of the compasses upon which the captain depended, what would be the effect of that upon the compass—even though it may be surrounded by a very large mass of copper? Does he think that it would have no effect upon the deviation of the vessel from her course?

MR. COLVIN: In the case referred to the effect would have been that the quartermaster forward and the quartermaster aft would notice that their compasses differed, and knowing that there was a difference the aft quartermaster would go forward and would steer by the forward compass.

DR. MOSES: I would like also to insert a saving clause. I assumed that the entire crew, captain, passengers and all, were in the highest state of excitement from a fire that was on board ship. We know some of the difficulties that would arise under those circumstances. Is it likely that there would be at such a time any comparison of the accuracy of the compasses?

MR. COLVIN: On a properly constructed ship—I do not know how it is in the merchant service, for there they sometimes save a good deal of money by not employing competent people—but in the naval service there are usually three people looking at the compasses at once—the signal quartermaster and two assistant quartermasters. As to your objection I will state that in the vessels on which I have been, there has never been any spar deck wiring on the upper deck; it has been done with battens under the spar deck, and by the regulations of the department the compasses are put so far from any vertical line and so far from a horizontal line; and the compass upon which they rely is usually some distance above the deck. All the other compasses could be lost or broken, and there would still be no danger on a properly equipped ship that that particular compass would vary so materially as to produce any disastrous effects. The suggestion is a very valuable one—about alternating currents—and one which I would take pleasure in communicating to the department, although I am not now connected with the service.

The President appointed as the committee to nominate officers for the ensuing year, and to name the place for holding the next meeting of the association, the following: Messrs. Eugene T. Lynch, Jr., E. R. Weeks, Frank Ridlon, H. D. Stanley and A. V. Garratt.

MR. DUNCAN: In view of our acceptance of the invitation to attend the meeting of the Engineers' Society at 8 o'clock this evening, and as a further fact that our committees are to have a meeting this afternoon, I move to now adjourn until 10 o'clock to-morrow morning.

The association then adjourned.

WEDNESDAY SESSION.

The Association met pursuant to adjournment at 10 o'clock A. M.

THE PRESIDENT: The first thing in order this morning is the reading of the report of the Legal Committee, which will be read by Mr. Arthur Steuart, of Baltimore.

MR. STEUART: I have the honor to make the report of the Legal Committee upon the question of improvements in our patent laws. The Legal Committee was constituted some years ago, and has been working along in an effort to arrive at some intelligent results on the question of improvements in our patent system. We all know the intimate relation that exists between the electric lighting interests and the patent system of this country, how closely they are related, and how much the growth of the electrical interests is dependent upon the perfection of the patent system, and we all know from personal experience the serious effects and disadvantages that exist in the system as it is now administered.

Mr. Steuart then read a paper following exactly the same lines as that presented before the American Institute of Electrical Engineers, and continued:

I have thus presented to you some views with reference to the desirable changes and additions to the existing patent laws which we desire to secure; and I have endeavored to show you the grounds upon which are based those views. I must also make a report of the work of the committee which I have had in hand during the last six months in attempting to bring about the results which are here outlined to some extent. At the meeting in Boston held last August, the Association passed a resolution authorizing the legal committee to introduce into Congress a bill providing for the creation of a commission to be appointed by the President of the United States, whose duty it should be to revise the existing patent laws, and report a bill to Congress at its next session, providing for such changes as they thought desirable. In pursuance of the preparation of that bill, and in looking over the ground to see whether the cause was a desirable one, I was met on all hands and on every side by the earnest opposition of the ablest and most careful lawyers in the country, those most interested in the patent system; and they came to me with this proposition: "You are doing a good work; you are in a good line; but there is an evil that we cannot escape; there is an opposing force that we must consider, and that is a deep-rooted opposition to the patent system as an element in our national policy that exists in some parts of this land. That opposition is represented upon the floor of Congress by a great many members; and any bill which is introduced of this kind, opening the door wide to revision, may have the effect (and the danger is an imminent one) of giving opportunity to these enemies of the system to come in and do the system harm." As the result of that advice (and I found the sentiment which prompted it very general and prevailing), the committee determined to change its course of action, and not to introduce that bill, but to frame another. The question of what that other bill should contain has occupied the mind of the committee up to this time. It has not been fully determined, but it will be very shortly. For the purpose of arriving at a solution of that question, and determining what that bill should contain, and for the purpose of interesting the members of the Association in the work of the committee, the committee entered into personal correspondence with every member of the Association, and also with every person whom they could find who was directly engaged in the electrical business. I think that I do not draw it too strongly when I say that they have been corresponding with not less than one thousand people throughout this country, and we have by that means been able to gather a mass of valuable information. The committee published a pamphlet, 2,000 copies of which were distributed among the members of the Association, the members of Congress and among others who were interested in the subject. They have more lately published another pamphlet, 1,000 copies of which have been dis-

tributed throughout the country, the purpose of which was to interest those whom we could reach on this subject, and get their minds into a condition so that when we were ready to present the bill we would be prepared to call upon them for their aid. I go from here to-night to Washington for the purpose of making arrangements in your behalf before the Committee of Patents in the House; and I have a memorandum here of several subjects which are now pending before the House Committee, which it is our effort to oppose. For the purpose of looking after this question the committee have been partially instrumental in organizing in the City of Washington a Bar Association among the patent attorneys in Washington. That association embraces the most important men in the profession in that city; and, being on the spot, we look with great confidence to their aid in opposing anything detrimental to the system, and in aiding us very materially in prosecuting our efforts before Congress. When I presented the subject to them I found that they were deeply interested in it, and anxious to join hand in hand with us in attempting to benefit this system. The meeting which will be held to-morrow will be attended by a number of gentlemen whom I have notified from different parts of the country, from Chicago, Boston, New York and Providence, all of whom will come to oppose the passage of certain bills which are now pending before the House. One of them is a bill which provides that patents not used in manufacturing, but held to control the trade, shall be vacated by due proceedings and at the instance of everybody who wants to use that invention. A second measure is an innocent purchaser bill (which you are probably all familiar with), which protects a man who cannot be proved to be a fraudulent user. The third bill is to give the circuit courts of the United States the power, at the instance of a would-be user of a patent, to take and examine the patent and determine what would be a reasonable royalty for that infringer, or would-be user, to pay for the use of the patent and to grant to him the privilege of using it without any restraint on the part of the owner of the patent. A fourth bill limits the right of the United States patent from 17 to 7 years. There are two other innocent purchaser bills, and two others which strike at the question which is now troubling telephone companies, and which may some day trouble you in your electric light business, and that is the interference of State Legislatures with the right of the patentee to use his patent, or the right of the owner of a patent to control the use of that patent. In Indiana the Legislature has passed, as you are all probably aware, a law which limits the price which shall be paid by its citizens for the use of the telephone. That law has resulted, in many cases, in the refusal on the part of the company to permit the telephones to be used at all, except on their own terms. This bill is now introduced (there are two of them) for the purpose of making it impossible for State legislatures to bind the owners of patents by such legislation.

All of these questions are vital questions, and they are questions which lie at the very root of the patent system. If any of these bills become laws the system will receive a very serious blow; and it is our duty in your interest to oppose their passage. At the same time that this meeting of the committee takes place to-morrow there will be a meeting for the purpose of opposing the passage of these bills, and there will be a number of gentlemen in Washington, many of whom represent the electric light interests—the Edison Company having promised to send their counsel, the Consolidated Company will send theirs, and the Westinghouse Company will send theirs, and we will have gentlemen from various parts of the country, all of whom are deeply interested in this question and in the effort to reform our patent laws.

The President has just handed me a memorandum which says that there are similar laws to those now in effect in Indiana before the legislature of our own State, which is now in session, limiting the price for telephone service to the same rate as is fixed in Indiana—three dollars per month. The probability is that we will at Washington concentrate our efforts upon two points only: one will be an increase of the salary of the Commissioner of Patents to such a sum as will justify a man of sufficient capacity in holding the position long enough to be able to establish some practice in the Patent Office which would be satisfactory.

A second will be to establish an intermediate court of patents, which will hear appeals from the circuit courts, and also from the Patent Office. This is the work which the committee now have before them.

Mr. W. W. LEGGETT opposed the action of the committee entirely, and argued that the question was one which affected not local electric light interests but the manufacturing interests. From the experience he had gained, he had come to the conclusion that the general interests did not like to see our patent laws changed. The remedy which he suggested as against infringements was the addition of a fine and imprisonment upon proof as in several foreign countries. As he could se little good to come of the work of the committee, he moved that the whole question be laid on the table, and that no more funds of the Association be applied to that purpose.

Mr. STEUART, in reply, stated that the work of the committee not only embraced needed reforms but included the prevention of the passage of dangerous bills, such as those now before Congress.

The subject was also discussed by the President, Mr. Foote and others, and, finally, on motion of Mr. Duncan the committee was continued, but without expense to the Association in its work.

On motion of Dr. Moses, Prof. E. L. Nichols, of Cornell University, was elected an honorary member of the Association, and appointed a member of the Committee on Insulation. Mr. E. G. Acheson, of Pittsburgh, was also added to the committee, but later on resigned.

On the report of the special committee appointed, Article VIII. of the Constitution was amended to read as follows: The annual dues shall be $20, payable in advance, and shall cover the calendar year.

The following paper was then read by Mr. Ch. A. Schieren, of New York, on

LEATHER BELTING, ITS ORIGIN AND PROGRESS.

In the early part of this century the first attempts were made by English machinists to transmit power by means of bands or straps made of leather; this transference of power from one line shaft to another, needed a peculiar quality of material, one that combined pliability, solidity and strength, and leather was the only known substance which suited that purpose. Many experiments have been made since then with other materials, such as rubber, textiles, wood, paper and even iron and brass; also belts woven of horsehair, etc., but none have been able to supersede leather, and even to this day it is universally acknowledged that

"There is nothing like leather
When well put together."

Belts made of leather are given the preference wherever they can be used, and it is somewhat strange that the machinery world of to-day knows so little about the origin, progress and growth of an article that plays such an important part in the transmission of power as leather belting.

For the benefit of those who have not read up the history of belting, I will give a brief account of the development of its manufacture in this country, and it then will be seen that this branch of trade has kept steady pace with this progressive age. Previous to 1820, and even up to 1835, much of our machinery, which then consisted principally of looms, etc., was imported from England and had all the necessary belting sent with it. These belts were made in a very crude way, generally from heavy leather, and were cut across the hides, so that all the laps or joints were from the belly part of the hide. These parts were lapped over from 6 to 8 in. and were not cemented, but were sewed together along the edges with white alum-tanned leather, similar to lacing; then large heavy rivets were put in the centre, and the whole thing made as clumsy and as heavy as possible.

In those days machinery was run at a very slow rate of speed, the belts had to bear a very severe strain and therefore generally proved unsatisfactory; so much so, that machinists became discouraged and used gear wheels and upright shafts instead of belting. Upright shafting was largely used in flour and other mills where heavy work is required as late as 1860.

Belt making up to 1840 was hardly known. Leather dealers and curriers, it is true, kept some extra dressed leather on hand for belting purposes, which mill owners and saddlers bought and made up into belting. All this stock was neither selected nor stretched, and the quality of belting it made can be easily imagined. In 1842 Wm. Kumble commenced the manufacture of leather belting at 33 Ferry street, New York. He also had a tannery in Frankfort street, where the bridge stores are now located. The foreman of this tannery, Mr. Fred. Wood, an ingenious and enterprising mechanic, invented some of the machinery necessary to stretch and join a belt in order to make it run smoothly, evenly and straight. Mr. Kumble gained quite a reputation at this, his new enterprise, and it was not long before he had several competitors. Thus, belt making became a separate and distinctive business, and before long, through Yankee push and ingenuity, we manufactured a belt which was far superior in quality and workmanship to any made in Europe. Since this we have not lost our advantage, but, on the contrary, have made such great strides in this line of business, that to-day it is universally acknowledged that the United States turns out the best belting in the world, and American belting is as much sought after in England and France as the Peep o' Day Yankee clocks are in England.

European belt makers are striving to imitate our methods of making belts, and for this purpose purchase our improved machinery, with which they hope to make a cheaper belt of equal quality and thus drive out American competition. However, I must return to my subject. My first illustration shows the method first employed for making a joint. This was, of course, found to be very deficient, and soon an improvement was made which consisted in champfering the end of the under lap, which came in contact with the pulley, so that the belt was much smoother and better.

Waxed thread was used to sew the belts and light rivets were used in the construction, which made it run easier, but as the leather was not stretched the belts would stretch all out of shape and the pulleys had to be flanged in order to keep them on. Not until Mr. Wood conceived the idea of stretching leather before being cut into belting was this trouble entirely obviated and a flange on the pulleys no longer needed.

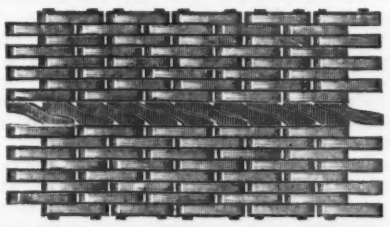
The inventions of Mr. Wood, however, are now superseded by more valuable improvements, which supply the present demand for perfect running belts, and the belts of to-day are as much superior to the belts of Mr. Wood's time as is the steam engine of to-day to the steam engine of 1840. When Mr. Goodyear invented belts made of vulcanized rubber, everybody thought that they would in time supplant leather. Rubber belting offered great advantages, being cheaper and made without joints, perfectly even and smooth, and apparently run much easier. However, many disadvantages were detected by actual use, and very soon rubber belts took their particular place in the use of belting, and are now manufactured in very large quantities; but for all swift running machinery leather is absolutely necessary and most reliable, and generally preferred.

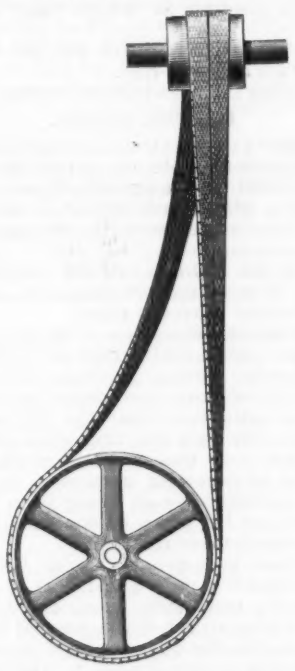
During the war the demand for belting increased enormously, and it taxed the facilities of the beltmakers to supply the demand. This made them somewhat careless, and the quality of belting greatly deteriorated. The aim of the beltmakers seemed to be how much of the hide they could put into belting irrespective of quality. At this time Mr. Underwood invented a method of making belts of pieces of leather six or seven feet long. He put short laps at both ends and covered the thin and flabby neck leather with splits which made them even with the butt ends. These belts proved to be total failures, and were soon abandoned. Mr. Underwood, however, made many other valuable inventions; his well-known copper shank rivets and burs, placed on the ends of laps to prevent them from raising, are still used by some; and his patent angular belts created quite a sensation when first introduced. The latter was a novel and ingenious invention. Great power could be transmitted with narrow angular belts, but they have outlived their usefulness and are now supplanted by other later inventions.

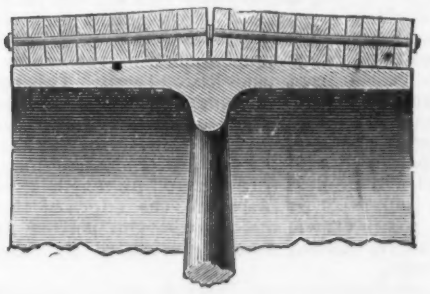
In the midst of this great demand for cheap belting, Mr. Joseph B. Hoyt revolutionized the trade by going to the other extreme. He gave orders that all of his belts should be made with short laps only, that the butt end should be joined to the shoulder lap, to accomplish which the whole shoulder had to be cut away. He ordered also that only thirty-six inches of the centre of the hide should be used, and that every width of belt should be stretched by itself. This was a most radical change and startled the trade, while it gave Mr. Hoyt a world-wide reputation for belt making, which he held until his retirement from business with a large fortune, a few years ago.

Mr. J. B. Hoyt deserves credit for having established a standard for belting which is reliable and cannot be surpassed, unless indeed the nature of the steer hide changes. The trade everywhere has been compelled to adopt this method of making belts, because customers have been educated up to it, and many of them will buy nothing else.

About 1865 our manufacturing industries developed to an enormous extent and immense factories were erected which required engines of great power, that could transmit from 500 to 1,000 horse-power. This created a demand for very wide main driving belts, and great difficulty was experienced by belt manufacturers in making wide main driving belts over 36 in., which would be of uniform solidity and equal tension. Whole hides contain on an average 36 in. in width, of solid leather, and never exceed 45 in., while orders came in from all sides for main driving belts from 50 to 75 in. in width. Ever since this time experiments have been made on wide belting, and to-day we have reached such a state of perfection that leather belts of any desirable width can be constructed.







RECENT PROGRESS IN LEATHER BELTING.

A main driving belt is now generally made on the following plan: Take for instance a double belt 6 ft. wide. The lower or running part of the belt consists of two pieces of leather of equal widths, cut from the centre of the hide and joined together parallel; then a 36-in. piece is placed in the centre of the two lower belts, and two end pieces filled out to the required width and all joined with parallel joints. This makes a belt of uniformly solid leather and equal tension, and one which is bound to run perfectly smooth and straight. Powerful stretchers have also been invented which can take in any width of leather.

Alexander Bros. patented a method by which they can use side leather and accomplish the same results. However, they do not make a parallel joint, but simply butt the pieces together as above shown and then cement and rivet the same.

Eastern belt makers were the first to produce a light double belt with neither rivets nor other fastenings, claiming that rivets and burs were not necessary if a belt was properly cemented. They were used for machines running at a high rate of speed.

About 1864 M. N. Clark, of Boston, Mass., made that line of belting a specialty. He produced a belt which would probably find great favor to-day for running dynamos. His method was to split the pieces of leather to a perfectly even thickness and then cement them together. This made a double belt, rather thin, but well calculated for high speed. Mr. Clark retired from business about ten years since.

Many experiments have been made to combine textile

materials and leather in the manufacture of belting. In 1872 Messrs. Clark & Slemmer, of Philadelphia, patented a belt of this kind. Their method was to stretch a heavy piece of cotton duck of the width required and place it between two thin pieces of leather of the same width. This made a strong belt which at first was received favorably by the trade, but which in the end did not wear well because there was two different kinds of material used; the cotton would stretch more than the leather, or vice versa, and the belt would very soon work itself loose and the cement and rivets break. Very few of these belts are in use at present. Another method is used which was patented by T. Thompson, of Cincinnati, and which is now manufactured by an Eastern concern. In this process, as in the other, a heavy cotton duck is stretched, a thin layer of leather splits cemented over its surface, and then the two sewed together.

These belts are used to some extent on dynamos. Their main weakness, as already stated, is the unequal stretching qualities of the two materials used, but this objection is not so marked when thin pieces of split leather are used, as above described. The atmosphere, however, exerts a great influence upon these belts, and they contract or expand with heat or cold, and cannot, therefore, be recommended except for easily adjustable machinery.

Edge cut belts are hardly known here, but are largely used in England for running machines where slow, heavy and positive motion are required, and they do excellent work.

These belts are made in the following manner: The leather is dressed and stretched the same as for ordinary belting; it is then cut into strips each one inch wide and holes punched at distances of one inch from each other, to admit of steel bolts being inserted. These strips are then placed side by side until the desired width is obtained, when they are bolted and riveted together. This makes a belt which is rather clumsy, heavy and stiff, but one that can stand more strain and hard work than any other belt made, and is very powerful.

This audience, however, is probably interested more in the progress and improvement made on leather belting for special use on dynamos and electric light machinery, than in the progress made in any other branch in the trade. I shall therefore describe different styles of leather belts which have met with great success in this field.

When the electric light first came into use electricians found it exceedingly difficult to get a belt suitable to use on dynamos. All of the belts which they tried seemed to lack something, and oftentimes the heaviest and most carefully made belts failed to do the required work. This problem received special attention by some of our most enterprising belt makers, and various methods for making these belts were introduced with more or less success. About five years ago the writer experimented on producing a belt which would be particularly fitted for transmitting power when run at a high rate of speed. I considered the stretching process of leather for dynamo belts the most important, because the steer hide by nature forms a peculiar shape, having fine and solid fibres on the back and then rounding off toward the belly with loose coarse fibres; to get therefore a perfectly flat piece of leather of even tension from the centre of the hide requires the utmost care.

The wide pieces of the centre are generally put into the stretching frame, leaving the short piece free, and thereby stretching the whole piece on an equal strain. Or, to explain it more fully, if you wish to stretch a 24-in. centre-piece of leather, you place your clamps 8 in. on each side and leave the centre 8 in. clear; this will draw up enough under the strain of the side pieces to be perfectly even; or, rather, the side-piece which contains more stretch will draw its tension even with the centre.

I also prepared a dressing or extra coating for the leather, which made it very pliable and also very smooth by filling its pores. Another important improvement for dynamo belts was making them light, double and perfectly even in weight, so that every square inch of the whole belt was of even weight and tension throughout. This caused the belt to run without vibrating like ordinary belts, to run more steady, and give a uniformity of power so necessary for producing electric light. Nor did the belt contain copper rivets and burs or other obstructions, but simply small wire endless screws; and its tensile strength was greatly increased by fastening the edges of the belt with these wire screws, which held the leather firmly together, and yet offered no obstruction to the smoothness of the belt.

However, no belt has ever created such a sensation in the trade as link leather belting.

This is a comparatively new article in this country, having been introduced two years ago. Since that time so many improvements have been made in this line of belting, that it can now be used on any kind of machinery. During the past two years these belts have done excellent work. They are made in the following manner: Small pieces of solid selected leather are dressed with tallow and Neat's foot oil, which acts as a lubricator to the joints of the pins. The leather is then put through rollers and made very solid; it is then cut into small links. This process makes a link of remarkable tenacity and strength, and one which will bear more strain than a piece of hard rolled sole leather. The links are then carefully assorted as to thickness and the belt built up to the required width. It is of great importance that each belt be made up of accurately-assorted links, in order that an even width and perfect running belt may be secured.

A joint is of great importance in this line of belting. Two bolts are used to each width of belt, and the two widths are ingeniously joined together, and form an unbroken surface. This makes a belt which will conform to any pulley, whether flat, rounded or cone.

They should be run as loosely as possible, and should not be taken up unless they actually slip. An inexperienced person upon seeing one of these link belts running on a dynamo would naturally think that the belt was loose and needed tightening, but these belts have such remarkable grip power that though when running the upper part of the belt is so loose that it almost described a semi-circle, the under side is as tight as possible. Leather link belts will in time find great favor with belt makers, as they are more pliable than any flat double belt can possibly be made, and for belts running at right angles I claim that they are the only reliable belts for such a position that will give satisfaction.

Mr. POPE: I would like to ask the gentleman with reference to the wearing of the edges.

Mr. SCHIEREN: The first belt which I made up about six years ago is still running. Before I came to this convention I took it down and told my man to take it apart, to take about six inches of it, in order to see the elongation. We have kept perfect time as to that belt. The belt is 28 feet 7 inches long, and it had stretched 9 inches in the first three months. After that there was no further stretching. We took the belt down, examined it closely, and found no elongation whatever. This belt is 3½ inches wide, one inch thick, and transmits fifteen horse-power under the following circumstances: It has two 38-inch pulleys, and the pulleys run at the rate of 125 revolutions.

In answer to a query from Mr. Pope as to the experience in Europe during the length of time that these belts have been running there Mr. Schieren said: In reference to the experience in Europe I will state that two years ago I was there and met several electricians and got from them some very valuable information with regard to the use of linked belting in running dynamos. Their dynamos there are run much slower than yours here. A great many of them favor these linked belts. They only use one pin there; and engineers told me that it takes four months before the pin adjusts itself to the rounding of the pulley. Although there are several patents there now, they make belts similar to what are made in this country. On the whole they speak of them very favorably. One belt is to-day running at the rate of a mile and a half a minute, or 8,000 feet per minute.

Mr. RIDLON: I have used one of these belts, three and a half inches wide, at a speed of 2,000 feet per minute. The only fault I can find with it is the stretching. We took that out two months ago, and there has been no trouble since.

Mr. M. D. LAW asked what success had been attained with almost perpendicular belts; and Mr. Schieren replied that good success was attained after the stretch had been taken out.

Mr. JESSE M. SMITH said that one of the greatest sources of loss of power in fast running belts—that is, in belts running 5,000 or 6,000 per minute—is the imprisonment of air between the belts and the pulley, and this is avoided with link belting.

The Association here took a recess until 3 o'clock P. M.

AFTERNOON SESSION.

Vice-President Weeks took the chair.

Upon reassembling Mr. Ridlon offered the following resolution:

Resolved, That article IV of the constitution be hereby amended to read as follows:

The President and Vice-Presidents shall be elected by ballot to serve during the following meeting. The Treasurer and the Secretary, who may be one and the same person, shall be nominated by the President, subject to the approval of the Executive Committee. The Executive Committee shall be chosen by ballot at each meeting, either annual, semi-annual, or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

On motion of Mr. Morrison this was laid over and made a special order for the next day.

Dr. G. A. Liebig then read the following paper on

ELECTRIC MOTORS.

The development of the electric motor from its primitive form up to the present state of advancement and usefulness has been similar to the growth of nearly all of those great discoveries, which have proved themselves at first so adaptable and then so necessary to the wants of every day life.

The history of the motor is a very remarkable one, not only as a story of rapid improvement, but also because its first chapters belong to recent times.

We can now ask ourselves, not without some astonishment, why it happened, seeing that the laws of the conservation of energy were so generally accepted, that the reversibility of the dynamo and motor was so lately discovered. It is quite true that the first motor was built many years ago, but for a long time even after the dynamo had undergone a very marked improvement, the motor was not turned to practical account. In other words, dynamos and motors have all along been kept distinctly apart, and even to-day their exists sometimes a certain indefiniteness about their relation.

We know that the general term "dynamo-electric machine" includes not only generators of electricity, but also appliances for converting electricity into other forms of energy, and that all the mathematical formulas which have even applied to the dynamo as a generator of electricity are equally as applicable to the dynamo when viewed as a source of motive power. The only changes necessary in our formulas relate to the algebraic signs of certain symbols.

The feature of reversibility is of extreme importance, and means that any rule of construction or of design that tends to make a dynamo machine an efficient apparatus will give identical results when used in connection with a motor. Other considerations may present themselves, such as questions of speed and output per unit weight of material, and these may be different in the two cases, but they are of a mechanical or, at any rate, secondary interest, and in no way effect the mathematical considerations. In what follows, therefore, we shall use the term "dynamo-electric machine" to designate, unless otherwise specified, either a generator of electricity or a dynamo reversed, *i. e.*, a motor.

In order to give an intelligible review of the work done on dynamos, and prepare the way for a few considerations which will follow, it may be well to describe briefly the component parts of a dynamo-electric machine, and refer to the purposes for which they are intended. In every dynamo we must have a combination of the following elements:

(a) An iron body or frame work constituting the magnetic limbs. This is always wrapped over a certain portion of its length with insulated copper wire and its purpose is to produce between its end or polar surfaces a region of magnetic force.

(b) A series of coils of copper generally wound upon a subdivided mass of iron, and capable of revolution about an axis in such a way as to make each coil pass successively before the polar surfaces of the magnetic limbs. This is called the armature and is always so placed that it helps with the magnets to form a nearly closed magnetic circuit of iron.

(c) A commutator which is merely the ends of the armature coils brought to one side, and which, revolving with the armature, effects a change in the direction of the currents formed alternately plus and minus.

(d) Several brushes or collectors, usually two in number, consisting of pieces of metal which press upon the segments of the commutator, and which are in metallic communication with the terminals of the machine.

In general the armature revolves between the poles of the electro-magnet, but in some machines, notably those intended to furnish alternate currents, the armature is stationary, and the magnet coils themselves revolve. This is, however, immaterial, inasmuch as what we have to consider is the relative motion of the parts of the machine, not their absolute movements.

It appears, therefore, that the dynamo machine, since it consists, broadly speaking, of an electro-magnet and a revolving coil of wire, is a very simple piece of machinery; yet it has taken years of hard labor and patient investigation to evolve from the spinning disc of Faraday the dynamo of to-day.

There is a feature in the history of the dynamo which must appear remarkable to every one thinking of the subject. When we remember how much attention has been directed to dynamo machines, not only by practical but by scientific men, and recollect that all the materials for a complete theory of the dynamo have been for several years at hand, we are inclined to wonder at the absence of such a theory. Even to-day no complete theory exists, though we are in an immeasurably better position in this respect than we were five years ago. For what we know now, in so far as it is so immediately applicable to dynamos, we are mainly indebted to the labors of Clausius, Hopkinson and a few others. It is sometimes claimed that the theory of the dynamo has been seriously crippled by the want of sufficient knowledge regarding the law of the electro-magnet, namely, the law connecting magnetic force with the magnetism thereby produced in magnetic bodies. If we admit that an empirical formula is required we must admit the justice of the claim, because no accurate expression of this kind has ever been originated. But we shall see that it is by no means necessary to depend upon emperical laws; all that we require are the curves of magnetism, and these have been before the world for years.

However, we now possess the results of a new series of investigations as to magnetism and a magnetic permeability undertaken at home and abroad, among which the most important are those of Hopkinson, Ewing, Rowland, Warburg, etc.; these results in connection with the work already referred to make it possible to calculate to a close approximation at least for certain forms of machines, just what any given dynamo will do when we know besides its dimensions and configuration the kind of iron used in its manufacture.

The word magnetic permeability used above, and which enters so frequently into dynamo calculations, is defined by Maxwell (Vol. II., page 50) as the ratio of magnetic induction to magnetic force.

It is also called magnetic inductive capacity corresponding to specific inductive capacity in electro-statics.

Following out an analogy in a different direction, it sometimes happens that magnetic permeability is called magnetic conductivity or resistance, the idea being to express the varying resistance offered by a given body to the production within it, of "lines of induction," as the lines of flow are opposed by a porous solid through which is forced an incompressible liquid. Further, we know (Maxwell, Vol. 2, page 51) that the magnetic induction is related to the magnetic force in exactly the same way that current is related to electromotive force, namely, we have

$$B = \mu H \text{ and } C = K E$$

where μ is the permeability and K the conductivity. But the analogy is in a sense imperfect, for whereas K is a constant, in so far, at least, as it is absolutely independent of the current flowing (leaving all heating effects out of consideration), μ is by no means a constant, but depends not only on the present state of the material in reference to the induction within it, but also upon its previous "magnetic history." Thus μ is a variable quantity, and for magnetic bodies grows less and less as the magnetizing force increases We can, therefore, regard the analogy between B and H on the one hand, and C and E on the other, as holding good only when H is a very small quantity.

In the calculations applied to dynamos it is extremely important to know the distribution of magnetism over the polar surfaces of the electro-magnets; that is, the number and direction of the lines of induction from pole to pole.

A solution of this problem can be arrived at mathematically in an approximate way only, and then, as a rule, by the consideration of what takes place in the least complex forms of surfaces. To attain certain ends the graphic method may be applied, either roughly by the use of iron filings, or more carefully by the employment of a small magnet suspended by a silk fibre. By observing the positions assumed by a small magnet when freely suspended in different regions of the magnetic field, we can form some idea of the form of the field. For we know that the direction given by the magnet coincides with the resultant direction of the magnetic force at that point (the needle being supposed so small as to exert no disturbing influence), and also that the relative number of lines in force in a small space surrounding the point measures the relative field intensity. The positive direction of the lines of force may be taken as from the north pole to the south pole, both outside and inside the magnet, and they are related to lines of induction in this way; outside the magnet they coincide; inside the magnet they are in opposite directions. This amounts to saying that the lines of induction are continuous, whereas the lines of force are not.

Other methods of measuring the field intensity of dynamos have been proposed, such as the magnetometer method. The results so obtained are, however, inaccurate and, indeed, the method cannot be applied at all when the armature is in place. Nor can the very simple pendulum method devised by Sir Wm. Thomson be applied, because the air space between armature and magnets is too small. It can, of course, be used by removing the armature and it has the advantage of giving results directly in absolute measure. Unfortunately, measurements obtained under these circumstances do not give us a reliable basis for calculations, inasmuch as the form of the magnetic field is strongly influenced by the presence or absence of the armature, at least when it contains iron. It may be remarked that magnetic distribution is exactly analogous to electric distribution, especially in the case of dielectrics, and that the geometrical form which influences the latter plays almost as important a part in the case of magnetic distribution. We are aware that the density of electricity in a given portion of a charged body depends upon the shape of the body and also upon the presence near it of other charged bodies. The same laws of sur-

face density determining the so-called leakage of lines of force obtain in the case of magnetism. In almost all dynamos the pole pieces have necessarily somewhat sharp edges and the number of lines of force per unit area is probably greater at the edges than over the remaining polar surfaces. This number is subject to a change when the armature is in place and to a further modification when the armature revolves, on account of the change in the direction of the axis of magnetization of the latter.

These considerations show us that any system of measurement which will give useful results must be of such nature as to be applicable to the dynamo when in working order. The ballistic method fulfills these requirements, it is sufficiently accurate, and besides involves no special difficulty. We have simply to surround that part of the magnetic circuit of which we want the induction with one or more turns of copper wire connected with a ballistic galvanometer and observe the throw of the galvanometer needle when the magnetism is reversed or reduced to zero.

It is always better to observe the elongation of the galvanometer needle due to a reversal of magnetism. An uncertainty always attends a reduction to zero owing to the phenomenon of residual magnetism. The galvanometer having once been calibrated in absolute measure we can from the throw of the needle calculate the value of the total induction within the wire and the magnetic force is known from the data of magnetizing current and number of convolutions.

The experiment is repeated for the different parts of the machine so that we finally obtain the value of the induction throughout the entire magnetic circuit. Suppose now that we have measured the field intensity and have a value of the induction per unit area; we can by Faraday's law calculate the E. M. F. which would be set up in a conductor moving in any manner in the field. The law is this: The E. M. F. produced in a conductor moving in a magnetic field is equal to the rate of cutting the lines of force. If the conductor forms a closed circuit, the E. M. F. depends upon the area of the circuit. Hence, in order to be able to determine the E. M. F. produced in an armature, say, we must know the area of the coils of the armature, the strength of the magnetic field and the velocity of rotation. Call the total number of lines of induction (flow of force) passing through the armature N and the current γ. Then, we have for the force x, acting when the circuit is displaced through the distance $d\,x$ by the principles of the conservation of energy, (Maxwell, vol. II., p. 137).

$$X = +\gamma\,\frac{d\,N}{d\,x}$$

Hence the movement is aided or resisted according as the number of lines of induction passing through the armature is increased or diminished by the movement. The work done during the displacement is

$$X\,d\,x = \gamma\,d\,N,$$

and if the number of lines of induction is changed from N to N', we have for the whole work:

$$\int X\,d\,x = \gamma\,(N' - N).$$

Let us divide both sides of the equation by $d\,t$ and we have:

$$X\,\frac{d\,x}{d\,t} = \gamma\,\frac{d\,N}{d\,t}$$

as the rate at which work is done. But $\frac{d\,N}{d\,t}$ is the rate at which the lines of force are cut by the moving conductor and is equal to the E. M. F. produced in that conductor. We have, therefore, for the rate of doing work—the activity:

$$\gamma\,e = \frac{E - e}{R}\,e,$$

the well-known expression for the activity of the motor.

We shall now briefly refer to the investigations of Clausius (1) and Hopkinson (2), as their work, though differing in character, is of extreme importance. The theories published by these two scientists are distinct and characteristic of the two ways of regarding magnetic phenomena. Hopkinson's method is based upon two fundamental laws of electro-magnetism; one law expressing the relation between currents and magnetic force, the other a condition which always holds for magnetic induction. They are as follows:

The line integral of magnetic force around any closed curve is equal to zero unless the circle surrounds a current, in which case it becomes $4\,\pi$ times the total current through the curve; the other is the equation of continuity applied to magnetic induction, which means that a line or tube of induction cannot end at a point in space according to the last law; therefore, if we find that the magnetic induction has different values in the different parts of the magnetic circuit composing the dynamo, we know that there has occurred a leakage through the air. For instance, the total induction through the armature in every dynamo is less than the total induction through the magnet limbs. The excess has, therefore, passed beyond the limits of the iron body into the air from pole to pole.

The two laws just given furnish a means of constructing the characteristic curve with considerable accuracy, *a priori;* that is, the curve showing the relation between electromotive force and current for the total induction nearly proportional to the induction through the armature at a given speed determines the E. M. F. generated The data required for calculating the line integral of magnetic force are first the general configuration of the dynamo, specification of the kind of iron used, the sectional areas and the lengths of the different parts of the machines, the magnet limbs, armature, yoke, pole pieces, and from these the "magnetic lengths" can, in general, be estimated. The variables chosen are the total induction through the armature, and the current around the magnets. Certain coefficients occur in the equations expressing the relation between the induction in the armature, and that in other parts of the dynamo, they are approximately constant, and can be estimated when their values for a machine of given form are once known. In a machine in which experiments were conducted by Drs. J. & E Hopkinson, the difference between the induction through the armature and magnets amounted to about thirty per cent. As an indication of the power of the method and the accuracy with which results obtained from one machine can be applied to dynamos of every different form, it may be recalled that the characteristic curve of the "Manchester" dynamo was constructed before the machine was built and was found to require no correction afterwards. In this case, the dynamo possessed not only an entirely new form but was also compound wound.

1. J. Hopkinson, *Proc. Roy. Soc.*, 1883.
2. Clausius, *Phil. Mag.*, 1883.

The theory of Clausius is founded upon consideration of a totally different character, as is undoubtedly less readily adaptable to practical manipulation. The theory is based upon Ampère's well-known laws of the action of currents upon conductors; an action which is supposed to take place at a distance and not through an intervening medium, as explained by Faraday, Maxwell, Thomson and others. Clausius expresses in his fundamental equations the mutual potential of the currents of the dynamo upon one another, and to determine the magnetic moments of the magnets and armature he adopts with, however, considerable unwillingness, Froelich's formula of induced magnetism. This formula has been extensively used and generally under the form:

$$M = \frac{a\,i}{1 + b\,i}$$

in which a and b are constants and i the current. There has always existed a more or less marked opposition to Frœlich's formula as not giving results in accordance with experiment, though the curve it represents is a practically straight line near the origin. Investigation has shown and Hopkinson has called attention to the fact that the curve should have a point of inflection at the origin, and hence it must be slightly concave downward (that is, toward the axis of abcissae) during the first part of its course.

Clausius has remarked that it would be better for a dynamo if the core of the armature remained stationary while the coils alone revolved. Mechanical difficulties, of course, preclude the possibility of such an arrangement; yet, we shall see that other considerations support the views of Clausius. In the case of two machines, one used as dynamo and one as a motor, the author has shown that the velocities of rotation necessary to secure maximum work are not in the ratio of one to two as generally believed, but approach this value as the speed of the generation is increased. This, however, refers to the condition existing when the work done by the generation is not limited. When the work is determined, he shows that there can be no relation between the speeds of the machines in order to give a maximum of work done by the motor. Another theory, though scarcely a distinctive theory, has been advanced by Dr. Frœlich, and much work of a theoretical character, besides that mentioned in reference to dynamo-electric machines, has been done; but the most important have been referred to.

There is one point which may as well be mentioned at this place about dynamo construction, which seems to have been the origin of exceedingly contradictory opinions.

It is in reference to the position which the coils of wire should occupy on the field magnets. In some cases we find the coils heaped up toward the middle of the magnets: in some cases toward the pole pieces, while in by far the majority of machines the coils are evenly distributed along the whole length.

Theoretically, the latter system of winding should be just as effective as the others, and being less complicated, should be used on that account. Prof. S. P. Thompson recommends in his work that the layers should be most numerous around the middle of the magnet limbs; in support of which view he calls attention to the form and number of lines of force from a straight bar magnet in which there is a leakage all along the bar from pole to pole.

The conclusion, however, is unwarranted and the comparison valueless, because in dynamo machines we are dealing with as nearly as may be closed magnetic circuits, and because the distribution of magnetism under such circumstances is entirely different from the distribution in bar magnets, whether long or short. The remedy for leakages which do occur is to be found not in the peculiar shape of magnet coils, but in the qualities of iron and lengths and sectional areas of the magnetic circuit.

The question of the regulation of motors now demands our attention, and we shall have to consider the methods adapted to meet the requirements of the two systems of electric distribution now in vogue. We can say two systems, because up to the present motors have not been successfully used on alternating current circuits, whatever may happen in the near future. The two systems known as the constant current or arc light and constant potential or incandescent lamp system necessitate methods of regulation in motors, which are entirely different. For constant potential work we can use either a shunt motor or a "compound wound" machine. In the latter, the main or shunt coils are in shunt with the armature and series coils or with the armature alone, the series coils being wound in a direction opposite to that of the main magnetizing coils. This system seems to have been first proposed by Messrs. Ayrton and Perry, and is described at some length in Thompson's book on "Dynamo-Electric Machinery." Bosanquet (*Phil. Mag.*, Vol. XV., p. 275) arrived at a law of winding similar to Ayrton & Perry's, but deduced from entirely different considerations. The elementary theory of machines of this type is too well known to require special attention. It is sufficient to say that machines so constructed regulate very perfectly (that is, run at a practically constant speed), and have been extensively used. It is, however, by no means necessary to employ a differential winding of field magnets as has been mentioned in order to secure regulation. The same results are attained by the use of a simple shunt arrangement, provided there exists a certain relation between the resistances of the shunt coils and armature. Indeed, many constant potential dynamos with excellent regulation have already been made in this manner, and motors on the same principle are rapidly coming forward.

It has been stated that compound wound motors (that is, shunt motors with series regulating coils) will not run at an invariable speed when the load changes, if supplied with a constant current, unless the speed is such as to reduce the efficiency to fifty per cent. or less. The statement seems inaccurate, an efficiency of fifty per cent. having to do with the regulation, as we shall see by examination.

Let us consider the matter for a so-called "long shunt" motor. Call now:

E, electromotive force of supply.
e, counter E. M. F. developed.
R, resistance of armature.
r_s, resistance of shunt coil.
r_m, resistance of series coil.

Then we have for the rate at which energy is supplied to the motor:

$$\frac{E(E-e)}{R + r_m}$$

and for the rate at which work is done by the motor:

$$\frac{e\,(E - e)}{R + r_m} = W.$$

Regarding now both with W and E as functions of the counter E. M. F., we have by differentiation:

$$\frac{dW}{d\,e} = \frac{E - e}{R + r_m} + \frac{1}{R + r_m}\left(\frac{d\,E}{d\,e} - 1\right)$$

$$= \frac{E - 2\,e}{R + r_m} + \frac{e}{R + r_m}\cdot\frac{d\,E}{d\,e}$$

If the potential of supply is constant, then $\frac{d\,E}{d\,e} = 0$, and the equation reduces to its first term. In this case we see at once that the differential coefficient of M with respect to e is positive or negative, according as $E > 2e$ or $E < 2e$. This means that as the load increases we can keep that speed constant by diminishing or strengthening the field, provided the efficiency is greater or less than fifty per cent., and this is well-known. Suppose now that E is variable, but that the current is constant; then we have:

$$K = \frac{E}{r_s} + \frac{E - e}{R + r_m}.$$

Differentiating, we have:

$$\frac{1}{r_s}\cdot\frac{d\,E}{d\,e} + \frac{1}{R + r_m}\left(\frac{d\,E}{d\,e} - 1\right) = 0;\ \text{or}$$

$$\frac{d\,E}{d\,e}\left(\frac{1}{r_s} + \frac{1}{R + r_m}\right) = \frac{1}{R + r_m};$$

or, putting $\rho = R + r_m$, we obtain:

$$\frac{d\,E}{d\,e} = \frac{1}{\rho}\cdot\frac{r_s\,\rho}{r_s + \rho} = \frac{r_s}{r_s + \rho}.$$

Substituting in our first equation this value of $\frac{d\,E}{d\,e}$, we get:

$$\frac{d\,W}{d\,e} = \frac{E - 2e}{\rho} + \frac{e}{\rho}\cdot\frac{r_s}{r_s + \rho}$$

$$= \frac{E\,(r_s + \rho) - e\,(2r_s + \rho - r_s)}{\rho\,(\rho + r_s)} = \frac{E}{\rho} - \frac{e}{\rho}\left(\frac{2\rho + r_s}{\rho + r_s}\right)$$

and, therefore, $\frac{dW}{d\,e}$ is positive or negative; that is, the rate at which work is done increases or diminishes as E increases, according as:

$$E > \text{or} < e\,\frac{2\rho + r_s}{\rho + r_s}$$

or, according as the efficiency:

$$\frac{e}{E} > \text{or} < \frac{\rho + r_s}{2\rho + r_s}$$

This quantity in the kind of motor under consideration is nearly unity, because the shunt coils have a resistance very great compared with that of the series coils or armature or both together.

The question of an efficiency of fifty per cent. does not therefore enter.

A better way to arrive at some knowledge of the regulation is to introduce an expression for the torque into our equations.

If we denote the speed by n and call T the torque or work per turn, we have for the rate of speed at which work is done in the motor:

$$W = n\,T = \frac{e\,(E - e)}{R + r_m}$$

This is usually called the activity. Differentiating this we have:

$$n\,\frac{d\,T}{d\,n} + T = \frac{1}{R + r_m}\left(e\,\frac{d\,E}{d\,n} + E\,\frac{d\,e}{d\,n} - 2\,e\,\frac{d\,e}{d\,n}\right).$$

Or substituting for T its value in terms of E and e and re-arranging we have for our fundamental equation:

$$\frac{d\,T}{d\,n} = \frac{1}{n\,(R + r_m)}\left(e.\,\frac{d\,E}{d\,n} + (E - 2\,e)\,\frac{d\,e}{d\,n} - \frac{e(E - e)}{n}\right).$$

Let us examine the case of a motor supplied with a constant current R and writing as before:

$$K = \frac{E}{r_s} + \frac{E - e}{R},$$

and assuming that the magnets are far from saturation, we have:

$$e = \text{const.} \times n\,N\,\frac{E}{r_s} = C\,n\,N\,\frac{E}{r_s};$$

N being the number of turns of wire in the shunt magnetizing coils, and C a constant. Solving for E and e, we obtain:

$$E = \frac{r_s\,R\,K}{C\,n\,N - (R + r_s)};\quad e = -\frac{C\,n\,N\,R\,K}{C\,n\,N - (R + r_s)}$$

and

$$\frac{d\,E}{d\,n} = \frac{r_s\,R\,K\,C\,N}{(C\,n\,N - R - r_s)^2};\quad \frac{d\,e}{d\,n} = \frac{C\,n\,N\,K\,(R + r_s)}{(C\,n\,N - R - r_s)^2}$$

Substituting these values in our previous equations, there results:

$$\frac{d\,T}{d\,n} = C^2\,N^2\,R\,K^2\cdot\frac{C\,n\,N + R - r_s}{(C\,n\,N - R - r_s)^3}$$

an equation of the second degree in n and representing the rate of change of torque. As R is too small to effect the sign of the fraction, it follows that $\frac{d\,T}{d\,n}$ is always positive; that is, the torque increases as the speed increases.

Furthermore, as $\frac{d\,T}{d\,n}$ is a function of n, the speed, the rate of change depends upon the speed itself, being greater for low speeds than for high speeds. However, the equation is only true within a limited range, for at great speeds the magnets would be extended through the armature reaction would practically change but little.

If we now regard E constant and suppose the motor to be a series motor, we have:

$$e = C n M . \frac{E - e}{R};$$

M being here the number of turns in the series magnetizing coils. This may be written:

$$e = \frac{C n M E}{R + C n M}.$$

From which we obtain:

$$\frac{d e}{d n} = \frac{R C M E}{(R + C n M)^2};$$

and substituting as before we have at once:

$$\frac{d T}{d n} = -2 \frac{C^2 M^2 E^2}{(R + C n M)^3};$$

which is of the third degree in M, but negative. Hence, the torque diminishes as the speed increases, and as before $\frac{d T}{d n}$ is different for every value of n.

Suppose, now, that we have a series motor supplied with a constant current K. Here,

$$e = C n M K \text{ and } \frac{d e}{d n} = C M K = \frac{d E}{d n}$$

$$\frac{d T}{d n} = \frac{1}{R n} \left(E - e \left[\frac{d E}{d n} - \frac{e}{n} \right] \right) = \frac{1}{R n}$$

$$[R K C M K - C M K)].$$

Or,

$$\frac{d T}{d n} = o.$$

That is, the torque being independent of the speed, is a constant.

Finally, let us consider the case of a shunt motor on a constant potential circuit. As before

$$e = C n N \times \frac{E}{r_s}; \text{ and } \frac{d e}{d n} = \frac{C N E}{r_s};$$

and by substituting and rearranging we have:

$$\frac{d T}{d n} = -\frac{C^2 N^2 E^2}{R r_s^2} = - \text{ constant.}$$

In the last two cases, therefore, the rate of change of torque with speed is a very simple expression. For a shunt motor supplied with a constant potential current, the regulation may be excellent, provided $\frac{d T}{d n}$ is a small quantity, but in no other cases have we even an approximate regulation. For constant current work we require a series machine, and the best method of regulation to be applied to it so far devised is a mechanical governor, which automatically changes the number of amperè turns in the field corresponding with the lead on the motor. Such a governor need waste but little energy, and may be as continuous in its action as desired.

Of the losses which occur in motors, we have in all cases to take account of those which are due to the following causes:

First. Heating of wires equal to:

$$C^2 R \text{ or } \frac{E^2}{R}.$$

Second. Foucault currents in pole pieces:

This depends upon number of armature sections, that is, fluctuations of current, and is generally small unless the Pacinotti form of armature is used.

Third. Foucault currents in armature. This depends upon (strength of field)^2, and in the modern laminated armature may be neglected.

Fourth. Reversals of magnetism of armature equal to $\frac{1}{4\pi}$ (coercive force) $\times$ (maximum induction) $\times n \times$ (volume). That is, it depends upon (strength of field)^2 and velocity of rotation. No amount of sub-division of armature core can effect this except in so far as it modifies the total volume of iron in the armature. However, a low magnetic resistance is necessary, and to secure this the armature must contain much iron. It is on this account that an advantage from a stationary armature coil would be derived.

Fifth. Momentary short circuiting of armature coils, depending upon coefficient of self and mutual induction of armature coils and strength of field.

Sixth. Finally, friction in bearings. This is difficult to estimate. If the belt is such that Morin's principle holds true, losses due to friction are constant.

In self-regulating motors the speed is constant, or nearly so; hence the causes of the dissipation of energy are confined to variable currents in the conductors and to changing field strength.

These, in compound wound and constant current motors, depend upon the lead, but, as we see at once, are practically constant for a properly made shunt machine. For a pure shunt machine, therefore, the efficiency, provided the speed does not change, is independent of the lead.

Before bringing to a close the few remarks which I have ventured to make on the subject of electric motors, it may be interesting to give a few facts regarding the growth of the motor industry, and to point out how various are the demands made upon these machines for manufacturing and commercial purposes.

Through the kindness of the Executive Committee of the National Electric Light Association I am enabled to bring before you a few figures which will, I trust, act as an incentive to increased activity in this direction.

The committee has addressed circulars to 234 companies engaged in electric lighting with the following questions:

1. Number of motors in operation.
2. Size of motor.
3. Maker's name.
4. Current used.
5. Charge per horse-power per month.
6. Charge per month per arc and incandescent lamp.
7. Results as to service.
8. Customers' opinions as to power and service.

As a result, answers have been received from fifty-six companies, and from these replies the following statements have been gathered:

Average charge per h. p. per month, 10 hours run	$10.00
Average charge incandescent lamp, 10 hours run	13.50
Average charge per arc lamp until 10 o'clock	9.83
Average charge per arc lamp until 12 P. M.	13.00
Average charge per arc lamp all night	22.00
Highest charge per h. p. per month	15.00
Lowest charge per h. p. per month	6.25
Highest charge per incandescent lamp per h. p.	21.00
Lowest charge per incandescent lamp per h. p.	11.25

The motors supplied with current have been used for the following purposes: Driving ventilating fans, collar and cuff machines, printing presses, various apparatus in repair shops, sewing machines, coffee mills, machines in gun shops, sausage machines, elevators, lathes, pumps, dams, ice cream freezers, organ bellows, appurtenances in laundries, etc., etc.

Sizes of motors have ranged from ¼ to 15 horse-power.

Twenty-six companies have supplied motors from arc light circuits. 14 from arc and incandescent and 16 from incandescent lamp circuits alone. In 34 cases subscriber owns motor and pays per month for current. In other cases companies own motors and charge rental for same.

Companies are endeavoring to have subscribers own motors in all cases and pay for the current. Electric light companies are satisfied and willing to enlarge the business. Customers' reports are also very satisfactory.

Although the number of cases cited above is small, it is still enough to show us how effectually the motor can supplant the steam engine, especially for those purposes for which the power required is small and under complete control. The opinion of those who have used electric motors indicates that they do their duty well, and encourages us to expect a brilliant future for this branch of applied electricity.

Mr RECKENZAUN: I feel very much interested in Dr. Liebig's paper, but I am afraid that the formulas which he worked out are not sufficiently practical for every day use. In the course of my experience in constructing motors and testing them I have found that neither Dr. Frœlich's nor Dr. Hopkinson's nor any of those elaborate theories have satisfied the conditions. Now if any one attempted to construct a motor on the formulas which Dr. Liebig gave us this afternoon, he would simply get into a fearful maze. He has first of all to ascertain several constants, and where is he going to get these constants from to commence with? He will not find them in any text-book. He will only be able to ascertain those constants by actual experiment: and as soon as a man begins to experiment and spend thousands of dollars, he does not want any more formulas at all, but he can at once construct motors according to experience. Now these things are very pretty and very useful to examine after the motor has been constructed, or after two or three motors have been constructed, to examine the relative value or efficiency of each. But until the motors *have* been constructed, these formulas are absolutely of no practical value.

Mr. Reckenzaun then referred to the work of Mr. Gisbert Kapp and the formulas * arrived at by him as of a most practical nature.

Dr. LIEBIG thought that this formula which Mr. Reckenzaun referred to, and which was certainly a very practical one, did not differ to any material extent from the Hopkinson formula.

Mr. H. MCL. HARDING: In regard to certain practical points we all want to know how much money we can make by selling electric power. Now, possibly a few figures which are the reports from about 80 stations which are now selling the electric current for power may be of interest. It is impossible to fix a price for any motor of any given size. That is to say you cannot take a 5 h. p. motor and charge $500 a year. That, you will see a little later, is not possible. All of you in trying to sell electric power have met that difficulty. The first thing to do is to divide all the classes of industries you intend to supply, say, into two or three classes: First, those requiring constant use. If you are running a ventilating plant and charge about $120 for one horse-power, that is constant use. You take next such things as printing offices and machine shops, all work of that kind, which we call partially intermittent. In that case the price has been established, and it would be well, I think, to have a price throughout the country in order to settle difficulties as to what the price of power should be, because the company seems to think that the one who is selling the motor wishes to have a very low price, and the one who is selling the motor thinks the company wants more than it is worth. First, be sure to sell the machine to the customer. Where motors have been rented the result has not been satisfactory. It has been tried by gas companies.

Steam companies have tried renting steam engines, but the engines are never cared for, and are in a wretched condition, and the same will be true of an electric motor. The repairs of the machines, after they have been run for a long time, not oiled and neglected, will more than eat up the profits. Take a half horse-power motor. The average price seems to be $75 a year. Of course, that is ten hours service. That would be equivalent to about twenty cents a day, which for sewing machines is not high. One h. p., $120; 2 h. p., $200; 3 h. p., $270; 5 h. p., $425; 7½ h. p., $600; 10 h. p., $750, and 15 h. p. up, about $70 per horse power per year.

These data we have obtained in this way: On every machine running on the constant potential circuit of the Edison Company in New York, and also in other places, they put a meter, and they examine the meter at the end of each month. These data have been of great value, because we know exactly how much the customer is using. In elevator work, as the third class, for a 5 h. p. motor you charge $300 a year; for a 7½ h. p. motor, $360. You can charge, say, about $400 for a 10 h. p.

Mr. FOOTE: I wish to thank the last speaker for his remarks. He has told me exactly what I came here to find out.

Mr. W. Lee Church then read a paper on

INDEPENDENT ENGINES FOR INCANDESCENT LIGHT STATIONS.

The service of electric lighting differs from other forms of manufacture in requiring more horse-power per square foot of floor space, in requiring higher speeds, in demanding the power in larger units, in compelling a closer and more uniform regulation, and in requiring more rapid and constant extensions. It will be observed that these peculiarities require individual and special treatment in the generation and distribution of power, and engineering practice as determined in other lines of manufacture may be sadly at fault when applied to electric lighting.

It has become an axiom among experienced station managers that the money is made or lost between the shovel and the belt. In other words, other things being equal, the dividend earning capacity of a station is determined by its steam plant, to which the electric apparatus is to that extent, in the nature of an accessory. Incandescent lighting has not until recently made a brilliant record as an investment, and much of the disappointment is directly traceable to the culpable ignorance of the principles of steam engineering which has been displayed. A man who will not venture to cut himself a $2.00 vest will not hesitate to exercise his amateur talents on a steam plant upon the economical and reliable performance of which depends an investment of one hundred thousand dollars and the public service of a city. A long and critical experience in this branch of industry has grounded us in the conviction that no incandescent station can hope to be financially successful under the ordinary conditions of competition unless based on independent dynamos belted direct from independent engines. Throughout this paper, therefore, we desire to keep constantly in view the opposite systems, namely, a station containing a given number of dynamos of two or three different capacities, each belted direct from high-speed engines of corresponding rating and, on the other hand, the same station with the dynamos driven from one or two slow speed engines transmitting their power through a line of countershafting and pulleys. Having these pictures well in mind we inquire: What are the essential requirements of a first-class steam plant in an incandescent electric light station? Taking them up in the order of their importance we unhesitatingly say first, and always foremost,

Absolute Reliability for Continuous Running.

The electric light company contracts to supply the demands of a diverse and exacting public, and that public expects to find its light on tap at every moment in the year. Failure of service in ever so small a degree is palliated by no excuse. Complete reliability is the condition of popular confidence and patronage, without which all other economies go for nothing.

Again, electric lighting, perhaps more than any other industry, has its earnings directly affected by the shutting down of its power, since it sustains a direct financial loss for lights out, aside from loss of custom and reputation, not easily regained. Subdivided power reduces this risk to a minimum, and, properly directed and applied, obviates it altogether. In a station using, 2,000 horse-power, say, in the shape of two large engines, loss in the lamps in one night by the shutting down of one of these engines is equal to one-half the cost of an independent engine on the subdivided plan. In other words, as tersely expressed by a manager of experience, "a company might better for peace of mind, reputation and cash balance on the books, throw a 60 horse-power engine into the scrap-pile than to shut down the station one hour." The service of electric lighting is similar to the editing of a daily paper in that time lost can never be regained. Most industries can make up lost time by working overtime and by pushing their business in various ways, but in electric lighting,

"The mill will never grind with the water that has passed."

Passing from argument to instance, we cite the recent experience of one of the largest stations in the country, operating in the neighborhood of twenty thousand lights. This station, as originally planned, was driven from a pair of Corliss engines, each having a cylinder 28 inches in diameter by 48 inches stroke and belting to a counter-shaft 4½ inches in diameter by about 50 feet in length. From this counter-shaft are driven five dynamos, having an aggregate capacity of six thousand 16-candle-power lamps. Clutch pulleys, 8 inches in diameter, are the means of disconnecting the dynamos when not in service, with similar clutch pulleys for exciters. The remaining dynamos in the station are each of 2,500 lights capacity, and each is driven by a 200 horse-power independent engine, belted direct. Recently, in the middle of the heavy run of the evening, one of the clutch pulleys broke in some of its parts, necessitating the immediate shutting down of the six thousand lights, besides doing considerable damage and involving danger to the employés. It happened that one of the independent engines with its dynamo was immediately available and was started within two or three minutes, so as to take up a portion of the load of the large engine. In this same station, at a subsequent time, a key became loose on the valve gear of the engine, necessitating another stop for several minutes. On still a third occasion the crank pin became uncomfortably hot, and was carried through the run only at great risk and labor.

Illustrations might be multiplied but this is used as one among many of the almost evident fact that no electric light station can afford to hang its whole business upon any one source of motive power, particularly when that motive power is distributed through the complex mechanism of counter shaftings, etc., involving risk of hot bearings, broken pulleys, defective clutches, etc., any one of which may shut down the whole station. Had these same dynamos been each belted direct from an independent engine the accidents above enumerated could not have occurred in the nature of the case. We do not assume to say but that accidents of some nature are due in any piece of mechanism, but the division of power and generating capacity into comparatively small units, each independent of all the others, affords a practical means of distributing the danger, so that it is essentially nil in its effects. That is to say, had a stoppage of any one independent engine in a similar instance occurred from any cause the other engines with their dynamos would easily have distributed the load for a short time, without any disturbance or danger whatever, and the service would have been uninterrupted while the repairs were being made or the difficulties remedied.

It has been incidentally remarked in another paper that independent engines afford a safeguard against danger from short circuits, inasmuch as currents of the short-circuit will overload an independent engine and slow it down, thus giving warning of the danger. If the dynamo is driven from a single large engine motive power will not respond to the short circuit until the short-circuit becomes equal to the full capacity of all the connected dynamos plus the range of power in the engine. Practically, therefore, single slow speed engine will not feel the short-circuit, but will pull through it until something burns away.

That merit of the steam plant which is most obvious,

* See THE ELECTRICAL WORLD, Dec. 4, 11, and 18, 1886.

and which appeals most strongly to the electric light company is:

Economy of Fuel.

The advocates of large slow speed engines rely upon the supposed superior fuel economy of this type as the sole offset to its obvious disadvantages. All managers unhesitatingly admit the superiority of transmitting the power directly and without loss from the engines to the dynamos, and more or less readily concede that in its performance the high speed engine will equal the running qualities and durability of the slow speed engine. If with this, say they, we could get the steam efficiency of the Corliss engine, no man would hesitate to decide in favor of the convenient, compact and independent small engine. We take the question at once by the beard, and desire to state that of two incandescent light stations operating under ordinary circumstances and otherwise equal, except only in their power and transmission, that one which has independent direct belted engines will show on its monthly report sheet not a small amount, but from one-quarter to one-third less coal per lamp hour than the station driven from a single engine through counter-shafting, both types of engines being non-condensing. We go yet further, and state that independent non-condensing engines under certain conditions will about equal in economy a slow speed condensing engine. This is a fact so incontrovertible when actually and candidly investigated, that we do not propose to demonstrate but merely to illustrate it.

We now submit to the prompt inquiry: "Will not a high-speed engine use more coal per horse-power hour than a Corliss engine?" Yes. "How much more?" Size for size and load for load, not over 10 to 20 per cent. Score 10 per cent. against the high-speed engine, and again ask: "Will not several small engines use more steam than one equivalent large engine even of the same type?" Yes. "How much more?" Load for load possibly another 10 per cent. Score 20 per cent. against the high-speed engine, and again ask: How an admitted loss of one pound of coal in every five can be reconciled with the statement of a monthly saving of 25 to 30 per cent. in favor of the independent engines? Answer: Simply because we have to deal with conditions as they exist in fact and not as we assume them to exist.

The reason why independent engines can overcome their moderate lack of initial economy, and pass a large percentage of actual economy to their credit, are mainly two. First: The use of a countershaft implies power to run it. Indicator diagrams show that the dead load of such a plant varies from 12 to 20 per cent. of the gross horse-power under full load when in ordinarily good condition, and not infrequently rises to 30 per cent. and over, with badly lined shaftings and badly drawing pulleys. Moreover, it must be borne in mind that the dead load is nearly a constant quantity, and if it amounts to 20 per cent. of the full load, it will under a partial load equal, and even exceed, the net power transmitted to the dynamos. It may easily happen every night in every station thus powered, that from midnight to morning two or three horse-power is expended in the cylinder for each effective horse-power recovered at the dynamo pulley.

Thus by one stroke and by a single item is the conceded advantage of the larger engine reckoned in the coal per horse-power practically swept away, and large and small engines left standing on an equal footing, prepared to submit to the still more searching question: "What is the cost from hour to hour of the power actually expended in meeting the fluctuations of the load?"

To consider for a moment some abstract facts in steam engineering we must note that the steam engine develops its maximum economy (*i. e.*, minimum consumption) only over a limited range of its power. Under normal conditions of pressure, say 80 to 100 pounds in the boiler, this minimum consumption is found only between the points of $\frac{1}{5}$ and $\frac{1}{4}$ cut-off, say from *a* to *b*, Fig. 1, at which latter point all engines are now rated. At its rated power, therefore, the single large engine of the Corliss type will consume as little as 26 to 28 pounds of water (steam) actually fed to the boilers per indicated horse-power per hour, and if the economy were not effected by the load we could represent the rate of consumption by the straight line *C D*. If overloaded, however, the rate of water consumption rises as shown on the right hand portion of the diagram, in which the horizontal distances represent the cut-off, and the vertical denominate the actual points of water consumption; the curve therefore, being a curve of efficiency at varying loads. It will now be particularly noted that, whereas the load rises for an overload it also rises for an underload, and very much more rapidly. This is well understood to be partly from excessive condensation, due to over expansion, and partly from the greater percentage of leakage under short cut-offs. Considering Fig. 1 to represent the actual performance of a 400 h. p. engine at varying points of cut-off, it will be seen that the engine *A* can be at its best only over a limited range, from *a* to *c*, or, say, from 325 to 450 h. p. An overload is, of course, mechanically injurious, which limits the possibilities in that direction. As the load falls off below 1-5 cut-off the steam rate increases in an enormous ratio, so that at 200 h. p. the engine is using 50 per cent. more than its normal rate, *i. e.*, at 200 h. p. the engine is actually using the gross amount of steam which would give 300 h. p. if used in a 300 h. p. engine. At 100 h. p. the waste is fully 100 per cent, and the steam used should develop not 100 h. p. but 200 h. p. if used in a 200 h. p. engine. It must be borne in mind that the diagram is platted from observation, facts, and is not a diagram of theoretical deductions.

It now remains to determine if the conditions actually obtaining in electric lighting stations are such as will enable a single large engine to develop its normal economy, and if not, then are they such as will enable the smaller independent engine, with a lesser initial economy, to reach a better gross result under the inevitable conditions as they are found to exist.

The typical daily chart of ampères delivered from an incandescent station of, say, 4,500 lights is shown in Fig. 2, of course, with variations in different stations, but always of the same general character. The chart is assumed to cover a winter night's run, commencing at 4 P. M. and shutting down at 8 A. M. The heavy irregular line *A B* represents the fluctuations of the actual load, such as would be determined by indicating a series of independent engines, and the area inclosed between it and the base line *M N* may be denominated the net power required. The fine irregular line *C D* incloses the gross load when driven by a single large engine, being equivalent to the net load plus the friction of the shafting and pulleys required in transmission. The irregular band lying between *A B* and *C D*, therefore, represents the dead load, which is a net loss, due to the friction of shafting.

But, as shown above, this is not the full measure of loss. We have already seen in Fig. 1 that an excessive underload requires a relative amount of steam which would be adequate to produce a much greater maximum efficiency. Combining the two diagrams, therefore, we would find a third dotted line *E F*, which would clearly represent the actual steam consumption required to secure the net work *A B*. The irregular band, therefore, between *A B* and *E F* represents the total loss expressed in coal. In other words, the entire area *E F M N* represents the lamps which should be got for the steam expended, whereas *A B N M* represents the lamps actually got for the steam expended. The loss involved is practically 50 per cent. of the total fuel in the whole night's run, which corresponds to observed results in stations whose fluctuations of load are about as indicated. Of course there are stations in which the net load averages more uniform than that shown, and a better proportionate result would, therefore, be expected from the single large engine with counter-shafting. We believe it safe to say, however, that there is no incandescent light station which will get a load so constant as to secure the economy from a single engine equal to that which can be realized from subdivided power.

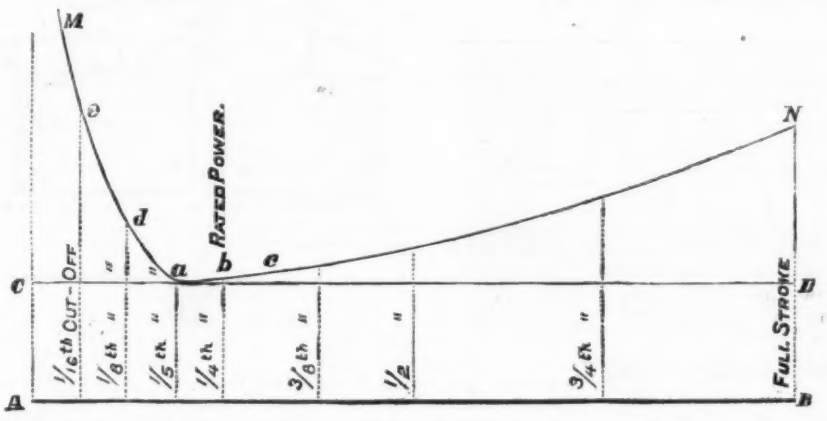


FIG. 1.—WATER CONSUMPTION AT DIFFERENT CUT-OFFS

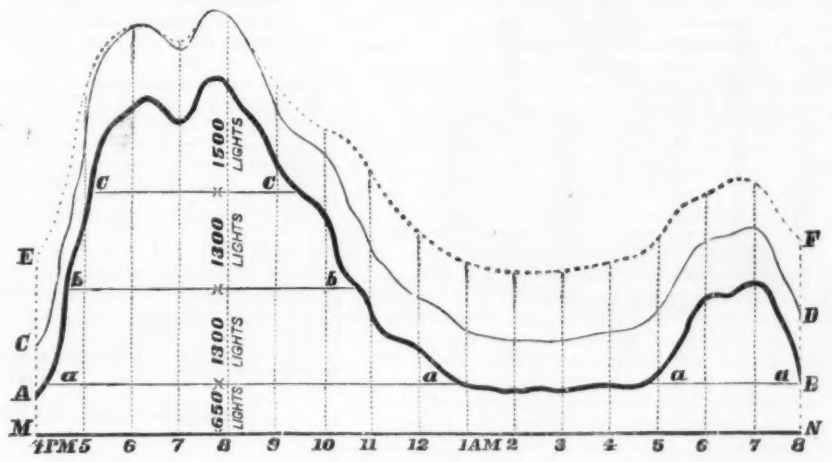


FIG. 2.—DIAGRAM OF LOAD IN INCANDESCENT LIGHTING PLANTS.

We now contrast the performance of independent engines in the same station. The lower narrow band between the lines *M N* and *a a* represents the smallest dynamo, equal to a load of 650 lights. The remaining three bands between *a a*, *b b* and *c c* represents the other dynamos, or successive loads of 1,300 lights each. At starting time, therefore, a 60 horse-power engine with its 650-light dynamos is started, and run continuously until shutting down in the morning. It will be noted that while running, the load on this engine is practically constant and at the point of maximum efficiency. In ten minutes after starting, the load on this rapidly increasing; it becomes necessary to start the second 125 horse-power engine, with its 1,300-light dynamo, which engine, again, runs on its full and most efficient load, as indicated between the lines *a a*, *b b*. This engine is stopped at 12:45, making another short run in the morning, and is, therefore, running to a disadvantage for about an hour. At 4:40 the increase of lights calls for the third engine, with its dynamo, which, in turn, runs until 10:45 and is then stopped. The fourth engine and dynamo will start at 5 P. M. and run until 9:30. The point to be clearly understood as vital to the whole economic question is that each engine while running is loaded to its best efficiency, runs only so long as its load is called for, then stops altogether, and with it all consumption of steam, leakage, radiation, wear and tear and loss of every nature. Ample time is given to inspect the engine and dynamo, if necessary, and the system, as a whole, develops the last possibilities of commercial efficiency.

The above diagram practically represents the performance of two stations which we once had the privilege of comparing, both of which were of practically the same size, and both constructed on the same electrical basis. We were by courtesy put in possession of the monthly reports from both of these stations, which showed a ratio between the pounds of coal per ampère per hour of 70 to 126 in favor of the station driven by independent engines. A station whose motive power is one or two large engines, therefore, finds itself in a position of earning money between starting time and 10 o'clock, and spending it again between 10 o'clock and morning.

We have thus endeavored to make it clear in the above illustration that the rated economy of the two types of engines is but a small part of the consideration, and cuts practically no figure whatever in actual practice under the conditions imposed by the nature of incandescent service.

If any one is now unthinking enough to inquire, Why not use a number of small Corliss engines in place of high speed engines if it is admitted that the Corliss type is the more economical of the two, we would answer, briefly: First, small Corliss engines are not as economical as small valve engines, the percentage of leakage due to the four valves and slower speed being much greater. Second, small engines of the Corliss type run necessarily at so slow a speed as to preclude the possibility of direct belting, and to involve full lines of counter-shafting, with their attendant cost and waste of power. Third, the first cost of small slow-speed engines is very greatly in excess of that of high-speed engines for the same power. We think no one has ever seriously considered, however, the adoption of small independent slow-speed engines.

Next in importance to reliability and economy is uniformity, delicacy, and continuity of regulation.

There is much misapprehension regarding the matter of regulation in engines used for electric lighting. Let us, therefore, ask: What is good regulation? Good regulation implies, as a matter of course, reasonably small variation in speed, reckoned in R. P. M., between the engine fully loaded and the engine running light. Claims are made that such and such engines regulate to 2 per cent., 1 per cent., and even $\frac{1}{2}$ of one per cent., under variations of load. Now, it should be clearly understood once for all that any decent automatic engine controlled by a shaft governor can be so adjusted as to regulate, not merely to 2 per cent., or 1 per cent., but to actually pass the point of exact regulation and run faster under load than when light. So far as regulation in terms of revolutions per minutes is concerned, 1 per cent. or 2 per cent. regulation is sufficiently close for all ordinary purposes.

Second. The most important consideration in the regulation of engines in incandescent stations is not their variations from minute to minute, but from stroke to stroke. An engine may make 300 turns per minute, counted for each successive minute of the hour, and yet may at any given instant be running sensibly above or below this speed, in the effort to meet a momentary fluctuation of load. We say every engine may do this, and we have observed that most engines do this frequently, the difficulty being, not a matter of the construction of the governor, but purely a question of lubrication. A perfect governor is one which will maintain the speed, not at an average of 300 revolutions per minute, but at the rate of 300 revolutions per minute for each and every stroke. Any properly constructed governor will retain the average of regulation to which it is set, but it can only secure instantaneous regulation when friction is practically eliminated. It has been our experience that nothing but a complete bathing of the governor in oil will practically accomplish this purpose.

Incandescent lamps require a regulation more delicate, perhaps, than any other industry. Any departure in regulation from stroke to stroke gives a variation of electromotive force which is speedily destructive to the life of the lamp, the item which, next to fuel economy, is the heaviest taxation. The injury is done during the period of acceleration immediately following the change of load, which period is the time between the change of load and the movement of the governor, and this in turn is proportional to the friction. It is obvious that if friction were annihilated the acceleration would be also nil, and the speed and consequently the electromotive force would never vary.

Third. Under the extremely long runs now imposed by electric lighting service, continuity of good regulation is essential. That is to say, a governor which will regulate when well oiled, will fail to regulate when its pins and bearings, being inaccessible under motion, have become dry during a long run.

As to the nicety of regulation obtainable from a slow speed engine there is no comparison possible. We have already shown that it is not permissible for an electric light engine to vary its speed, even from stroke to stroke.

All observers know that it is frequently quite possible to count the revolutions of a slow speed engine, particularly when heavily loaded, by the pulsations in the lamps at a distance from the station. A slow speed engine, unless excessive in its fly-wheel capacity, will imperceptibly slacken in passing its centres, and this variation, not visible on the engine, becomes a sensible and dangerous variation when multiplied to the speed of the dynamo. The fluctuation of the needle of two voltmeters respectively registering from a high speed and slow speed engine will give abundant evidence on this point.

Flexibility.

The characteristic of flexibility in electric light stations is one which is frequently overlooked until experience, except in stations where the lowest dynamo is small enough for the minimum unit, demonstrates its desirability. To secure the best possibilities in this direction it is necessary to use dynamos of two or three different sizes, say, of 650 1,300 and 2,500 lights capacity, each being driven direct from its independent engine. The plant being thus divided into independent units of different sizes, any variation of demand, either in the total load or in the load required for

different circuits, can be conveniently met. Owing to local causes, the load of a station is not necessarily the same from day to day. It is obvious that a plant in which all the dynamos are hung upon one, or, at most, two, engines, is essentially rigid in its control of circumstances, whereas a station planned as above indicated is to the last degree flexible in meeting any variations of load to whatever degree they may occur. All this has a direct bearing both on economy of fuel and incidentals of operation.

We would not wish to imply that the smallest unit in every station should necessarily be the smallest unit as determined by the minimum load existing at any considerable time during the day. This minimum load in the majority of medium sized stations will represent about ¼ to ⅓ the generating capacity of the station. That is to say, a station of 4,000 lights capacity should have one dynamo at least as small as 650 lights. Beyond this it is, perhaps, advisable that the units be uniform for the sake of interchangeability of parts. The whole question of units of generation must be considered, not in the light of any one rule, but under all the circumstances of each particular case.

Maintenance of Plant.

The maintenance account of a plant often defeats dividends. In the use of counter-shafting an entirely new factor of expense is introduced, pertaining to the shafting, bearings, pulleys, clutch pulleys, belts, etc. Each bearing of the counter-shafting will consume oil to the value of at least $5 per annum, and any considerable amount of shafting involves the pay of an extra oiler to properly care for it. Regarding the two types of engines under discussion, it is, undoubtedly, true that the maintenance of the high speed engine will be fully as low as of an equal horse-power in slow speeds, as to its actual expense, without taking into account the time lost in repairs. Nearly all high-speed engines are made to gauge with more or less reference to interchangeability of parts. Repairs in consequence are furnished at a minimum of cost, and, the parts being light and readily handled, the engine can be stripped and overhauled, and connected, without the employment of an extra force of men or the necessity for heavy handling. In referring to high-speed engines we, of course, only speak of those which are carefully and understandingly designed for the work put upon them. That is, we wish to draw a sharp distinction between high-speed engines and engines speeded high.

The one danger to high-speed engines arises from the possibility of charging the cylinder with water which cannot be quickly enough relieved through a valve at the speed at which the piston travels. The fact that no engineer justly entitled to the name should ever allow an accident of this nature to happen does not, in the public mind, shift the responsibility from the maker of the engine. Spring relief valves have now been brought to a state of perfection which leaves little to be desired, when the engine is of a type permitting their use.

Space Occupied.

This is one of the minor considerations which in certain locations becomes of considerable importance. Not infrequently electric light stations are located near the business portion of the city, where real estate is valuable, and taxes correspondingly high, and space counts heavily in the capitalized investment. Again, a large building obviously increases the investment, particularly when that building to carry heavy lines of shafting at high speeds must be of unusually massive construction. It needs no illustration to show that independent engines by doing away with the space occupied by counter-shafting and belts, under the least distance between centers which can be justified, require materially less space per horse-power than any form of non-subdivided power. This is particularly the case where the dynamos are placed on the second floor, over the engine room.

Moreover, the cramped space in which the single engine must develop and distribute its power is against its satisfactory performance. The fact is generally overlooked in drawing comparisons that a single large engine in an ordinary manufacturing establishment, such as a cotton mill, has in the nature of the case a wide space in which to transmit its power from the slow motions of the engine up to the high speed of the spindles. This means that ample space is given to bring the speed by gradual accelerations, through easy moving shafting of substantial nature up to a moderately high intermediate speed, and then distribute it to the spindles in small quantities by means of simple and light fast running devices. In the dynamo room, on the contrary, the space is cramped to the last degree, and the slow running engine must in a short range multiply its power to high velocities, and transmit its speed in large units to the dynamos. The whole system of transmission becomes rigid and ineffective, and the loss consequent upon friction and risks to employés, and the magnitude of disaster when any occurs, are such as in themselves to overbalance all the economy which the most enthusiastic advocates of slow speed engines attribute to them.

Extension of Plant.

An electric light station, unlike most other industries, is usually of very rapid and persistent growth, to an extent which is not generally foreseen in the original calculations. The use of independent engines lends itself readily to indefinite extension. The power and dynamos both being divided into like units, each independent of the others, extension becomes merely a question of more units, without any special preparation in the plan. On the other hand, the slow speed engines with counter-shafting are necessarily in large units, and to that extent fail to meet the requirements of a gradual increase. The use of the large engine involves an outlay disproportionate to the immediate returns from the first increase ordinarily provided for, and it necessitates also the operation of the moderately increased plant at a great disadvantage on account of the underload involved, as already explained. The practical operator will readily see the force of this important advantage on the side of the independent engine.

First Cost of Plant.

This consideration, although really of the least importance among those enumerated, is distinctly on the side of subdivided power. The price of high-speed engines per horse-power is now fully as low, and generally lower, than that of slow-speed engines. Cost of foundations is materially less, as is also cost of erection and handling for repairs. There, then, comes into the question the clear saving of all money invested in counter-shafting, pulley blocks, heavy belting, clutch pulleys, receiving pulleys, and similar devices. In the station to which we referred above, the extra transmitting devices necessitated the investment of a sum not less than $6,500. The price thus expended for worse than useless machinery would be sufficient to purchase practically 500 horse-powers of independent engines, adequate to maintain 6,000 lamps, showing a net earning capacity of at least $18,000 per annum. When we contrast this with the net losses due to the system of concentrated power, as above discussed, it leaves no room for argument as to the advantages of independent engines in electric light work.

This was followed by a paper by Mr. Jarvis B. Edson entitled

ECONOMIC VALUE OF STEAM PRESSURE RECORDS.

The engineer of the present century begins his operations based upon the pressure of steam he is capable of maintaining in his steam boiler. From this he extends his calculations, and elaborates his plans for the prosecution of his work. It matters not what the problem may be, whether it is the grain to be threshed, grist to be ground, hills leveled or mountain pierced or raised, or office reached, ocean plowed or continent crossed, the same agent performs them all. The tropical fruit while rushed to a Northern market is also cooled by it, and the plethoric meat of the Western plain is refrigerated during its transcontinental run, till finally we see the coal transformed into heat, then into steam and manifesting itself in work, in its production of coal exemplifying the beautiful law of the conservation of energy and making us thankful for the birth of steam. At present the civilized world is lighted by it, and searching for one greater than Faraday who shall give us a substitute and sound the death knell of steam. So meanwhile we reconcile ourselves to the loss passing up the chimney and stand aghast when the boiler "lets go," scattering death and destruction in its wake, and simply conclude with a verdict of "nobody to blame."

Investigation and scientific study have done much, however, both for the construction and the safe economical management of steam boilers. Mystery no longer accounts for boiler explosions, for the conclusion has been reached that "the cause of such accidents can be wholly prevented and controlled," and ignorance is becoming dethroned in their management to make way for the more intelligent methods of boiler management. The men from our colleges and technical schools demand the facts that they may proceed to their conclusions intelligently—not theirs, to view the 135 victims of a "Westfield" explosion with "nobody to blame," for it is not they who beat upon pans and blow horns to scare the "devil" when the sun darkens. The solar eclipse to them was calculated upon and predicted in advance of its coming. Their verdict will always be, Somebody is to blame, explosions are caused by ignorance or neglect.

And so with economy, for to them the furnace will be a sort of gas retort and the burning of coal a scientific study. To them, the boiler, is a giant struggling against almost equal odds, harassed by conflicting expansions and contractions, constant and varying strains, attacked by corrosion and injured by scale. They will know it is a magazine of enormous power in which each cubic foot of water has the explosive energy stored within it of a pound of gunpowder, and to them eternal vigilance will be the price of safety. Certainly then it does appear strange, that for such a charge we should employ cheap labor, that the most ignorant man about the establishment is the favorite fireman. For my part it is incomprehensible sagacity that can feel willing to discount the chances against such a course.

Nevertheless, the engineer of to-day is confronted with these conditions and the safety and economy of his "plant" become of imperative importance to his success. In these two connections then, I desire for a few moments the indulgence of your attention, with a view to submitting to your judgment certain facts bearing upon the importance of providing some method whereby a surveillance over the steam pressure may be had, for accurate and full information as to the management of our boilers should always prove useful and interesting.

Upon the question of safety it requires no demonstration to prove that whatever impairs the boiler's strength or durability should be prevented.

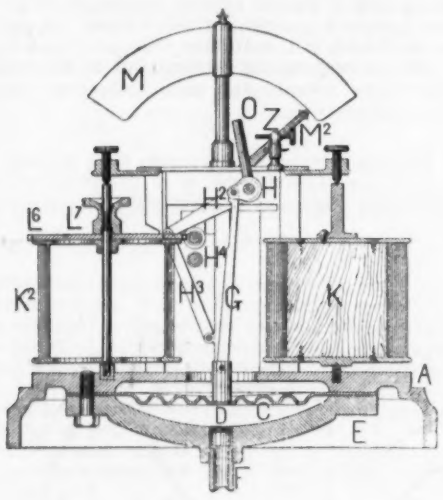
To make such prevention possible, however, presupposes the means whereby the preventable occurrence may become known. If, therefore, fluctuating or excessive steam pressures are injurious how are we to be made aware of their occurrence?

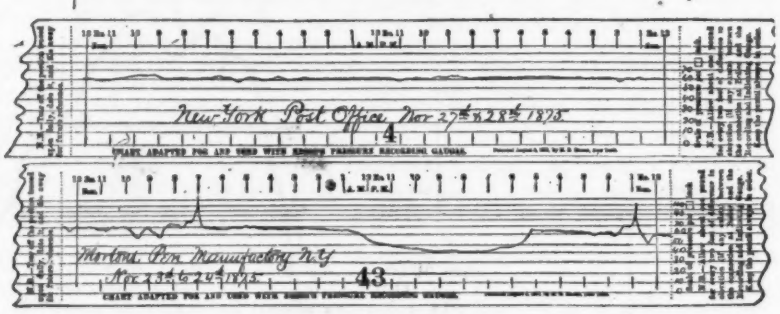
Obviously but one method exists, and that is the resort to automatically steam written records of them, and from which we can determine the departure from conservative limits. Assuming that the ordinary steam gauge, which only indicates the pressure at the instant, is entitled to the great confidence bestowed upon it, it undeniably lacks the ability to afford us any more information as to the pressure of the previous moment than the proverbial dead man, who can tell no tales. In fact, for many years, owing to sharp competition, they have been so poorly constructed as to be even dangerous to use, so liable are many to rely upon them for the determination of the pressure they are at the time carrying, even going so far as to adjust their safety valve weights to blow with the gauge. The dials are first produced by different methods in large quantities all alike, and the springs taken afterward which will come the nearest to the "travel" called for by the dial so laid out, whereas each spring has its own "travel," and its dial should be laid off accordingly and a suitable price demanded for the article when made, as a cheap and unreliable steam gauge is dangerous and dear at any price.

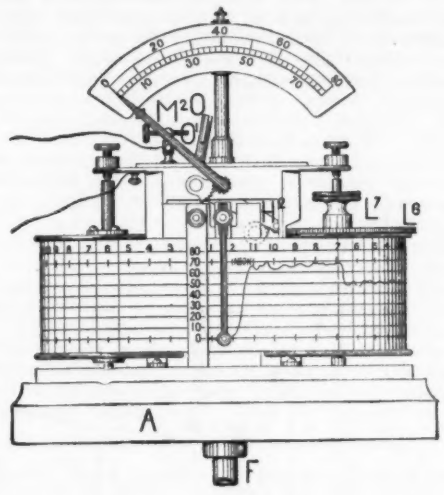
When, however, only one of these is relied upon for 20 years it is apt to be considerably out. Last month I came across one such in a State hospital which was some ten pounds out, and in which case the pipe leading to it was stopped up by dirt, etc., so the pressure rose and fell, not with the pressure, but soon after change occurred as the condensed steam, "water," could soak through the obstruction.

Instead therefore of relying solely upon the ordinary indicating instrument, whether it be entitled to such confidence or not, common prudence would dictate the employment of more than one gauge and preferably that the supernumerary should be a recording machine.

The records of steam pressure carried have a large prudential value for the reason that with their use a fireman must give up his position or do what he is required. For instance, if a careless man lets his steam get too high before he discovers it and the safety valve does not blow as calculated upon from any of the causes common in such cases, who other than the fireman will be any the wiser, and when will the remedy for a careless fireman or faulty or overloaded safety valve be applied.







RECORDING STEAM PRESSURE GAUGE.

It is obvious but one method exists, and that is the resort to automatically steam written records of them, and from which we can determine the departure from conservative limits. Assuming that the ordinary steam gauge, which only indicates the pressure at the instant, is entitled to the great confidence bestowed upon it, it undeniably lacks the ability to afford us any more information as to the pressure of the previous moment than the proverbial dead man, who can tell no tales. In fact, for many years, owing to sharp competition, they have been so poorly constructed as to be even dangerous to use, so liable are many to rely upon them for the determination of the pressure they are at the time carrying, even going so far as to adjust their safety valve weights to blow with the gauge. The dials are first produced by different methods in large quantities all alike, and the springs taken afterward which will come the nearest to the "travel" called for by the dial so laid out, whereas each spring has its own "travel," and its dial should be laid off accordingly and a suitable price demanded for the article when made, as a cheap and unreliable steam gauge is dangerous and dear at any price.

When, however, only one of these is relied upon for 20 years it is apt to be considerably out. Last month I came across one such in a State hospital which was some ten pounds out, and in which case the pipe leading to it was stopped up by dirt, etc., so the pressure rose and fell, not with the pressure, but soon after change occurred as the condensed steam, "water," could soak through the obstruction.

Instead therefore of relying solely upon the ordinary indicating instrument, whether it be entitled to such confidence or not, common prudence would dictate the employment of more than one gauge and preferably that the supernumerary should be a recording machine.

The records of steam pressure carried have a large prudential value for the reason that with their use a fireman must give up his position or do what he is required. For instance, if a careless man lets his steam get too high before he discovers it and the safety valve does not blow as calculated upon from any of the causes common in such cases, who other than the fireman will be any the wiser, and when will the remedy for a careless fireman or faulty or overloaded safety valve be applied.

It is generally supposed to be necessary to first know of a trouble before its remedy can be either determined or applied.

The only way, therefore, to know whether one's boilers are being exposed to excessive pressure or not is to use a gauge which records the pressure.

Occurrences are constantly taking place under that smooth sounding term "banked fires" which would electrify every hair of one's head if revealed to those who have so much at stake and think such a fire harmless. A strong fire towards stopping time leaves the boiler setting so hot as to supply sufficient heat for running up the pressure beyond what a cold setting could do. Yet when the fires are once "banked" the man "lets up" on his watchfulness, and generally the boiler is left entirely alone for a long interval. "We never carry steam at night, as we bank our fires, and in the day time have a good careful man around," is an expression common to most steam users; but a few moments will generally convince them that they have assumed a very ridiculous and untenable position. The police of our cities frequently find steam blowing off from boilers under the sidewalk during their night perambulations, and have learned that it means one of those places where they "never carry steam at night," and he routs out somebody in the building or neighborhood to remedy the trouble. One summer, recently, while stopping in a manufacturing town, I heard a shrill whistle blow for two or three hours during the night, and concluded, as I learned the following morning, that it was a low water alarm. The police hunted up an engineer to go to the establishment and give the boiler some water; and fortunately the boiler took the engineer's proffered kindness without getting up and going off out of shape about it, either.

A case occurred last October under one of the costliest buildings on Broadway, New York, where fires are banked and they "never carry steam at night." It appeared, however, from the recording gauge chart the next morning that something had caused the recorder to make a high steam line for a good part of the night and investigation proved that the night watchman heard a roaring noise when in the top of the building and concluded it must be the boiler "blowing" about something, so he clambered down twelve or thirteen stories and found the damper closed and a full pressure on. Of course it goes without the saying that if the valve had been fast in its seat, or the weight shifted on the lever from any cause, a first-class explosion would have followed. The boilers are provided with an approved pattern of damper regulator on the main flue and also have individual dampers on the branches from each boiler leading into the main flue. The individual dampers are, of course, for shutting off either boiler when not in use. The trouble was caused by the

fireman not knowing enough, or forgetting to unhook his automatic regulator connection before leaving for the night, and so when the banked fire and heated walls had radiated sufficient of their heat, the pressure of steam closed the damper, and the heat being entirely shut in and no cold air passage left open to the chimney and little or no steam being used in the building, the "safety valve" was called upon and fortunately did its duty and prevented the steam passing beyond the limit, as shown by the chart.

In the same establishment only two months later, on New Year's morning, the night watchman closed the furnace doors at the usual hour so the fires would be in better condition for the day fireman when he arrived, but the day man did not arrive until some two hours later than usual as it was a holiday, and so the steam went up again and startled the neighborhood with the racket for an hour or so. The day man claimed that he told the watchman not to close the doors until a later hour, which the latter denies. Be it all as it may in both instances, the chart daily submitted to the manager of the property revealed the occurrences and brought forth an investigation resulting in more correct methods of transmitting orders and causing the unhooking of the regulator while under "bank fires," and also in the night watchman making more frequent visits to the boiler room. Who can deny but that in this instance, their indifferent methods would ultimately have resulted in exploding their boiler had not the recording gauge unmasked the facts and caused the proprietor to set some needed rules in force. If an ounce of prevention is better than a pound of cure the instrument repaid its first cost in these two instances alone.

Self interest should suggest the use of such a safety appliance, particularly, inasmuch as all persons are supposed to intend the natural consequences of their acts; for proof of an act, or course of procedure, which was adopted or persisted in to deceive the public or in defiance of its safety, is sufficient proof of the intent to deceive and jeopardize unless the doer establishes innocence of such intent and knowledge, and the burden of proof rests on him. If, therefore, it be true that no steam boiler "plant" can be conducted as intelligently, economically, or safely without the information and aid supplied by the pressure recording instrument as with it, then proof of negligence can be made out by establishing the fact that such a valuable monitor and means of information as the pressure recorder had been rejected, and failure to secure such competent attention may be properly urged in courts of law as evidence of negligence.

Even so important a matter as the amount of pressure applied by an authorized inspector in testing a boiler with hot water has shown that only an excess of 8 lbs. was put upon an old boiler which is regularly carrying from 55 to 60 lbs. pressure of steam. The record further shows the pressure to have been "jumped on" for an instant and then released, allowing no time for careful inspection while under the testing pressure, of the seams, etc. No satisfactory reason has been obtained so far for this improper method of testing, but the fact has been established, and so much gained. Certainly more confidence could be reposed in a test where the record shows that the boiler sustained the testing pressure for five or ten minutes, and during which time the testing engineer could be presumed to have been examining the boiler for evidence of effect under such strain.

Another matter revealed frequently by the recording gauge chart is the habit indulged in by many attendants, called "bottling up steam." The most frequent occurrence of such habits takes place at a few moments before the starting time in the morning, and at noon, and in some cases just before cleaning fires. Of course such prejudicial habits are the simple outgrowth of ignorance, concerning the limited amount of steam in quantity they can so bottle up, and the very small service it can render, compared with the injury such practice, when persisted in, ultimately does the boiler. Aside from this objection, the habit is exceedingly pernicious, because only a few moments neglected would cause the pressure to accumulate to the point at which the safety valve is supposed to open; then, if it happens to be inoperative, an accident is almost certain to follow. No excuse should be taken in any shape, under any kind of reasoning, for "bottling up steam." If the generating capacity of the boiler is not equal to the current demand, it cannot be helped by simply bottling up; in fact, it has been my experience that where the record line has been extremely crooked upon the first introduction of the recorder, the effect of such record has been to cause a much more uniform use from day to day until the nearest approach to uniformity had been reached consistent with the vicissitudes of the demands for steam.

A steam user once apologized for the appearance of his record, saying that the steam was drawn from the boiler at irregular periods by persons in the mill, and consequently the fireman could not carry any very regular line; that his use of steam was different from that in most places, etc. Noticing, apparently, my incredulity, he asked if I disagreed with him. My reply was, "Do you suppose that the steam necessarily falls as low as this record indicates?" In other words, I called his attention to the fact that where a fireman is on the keen lookout for his boiler pressure and water level he will readily detect the pointer hand of his gauge the moment it begins to rise or fall and govern himself accordingly. For instance, if he sees the hand indicating that the pressure is falling he will avail himself of the opportunity to slow down his feed, and perhaps open his damper wider, and, if his fires are in prime condition, withhold fresh coal for a few moments; then, when the onslaught upon his boiler has ceased and the hand of his gauge is stationary, or starts to move upwardly, he will at once set about it to replenish his coal and water and so have his conditions favorable in a few moments for another attack upon his steam supply. When his steam is rising he can afford to feed and to fire, and his thought should be to have everything in prime condition while he has surplus power and opportunity. Then he would not be caught so badly when these extreme attacks were made upon him. The case of these extreme fluctuations, then, is largely due to the fact of his being unprepared to meet these emergencies, and becoming alarmed when his steam has fallen twenty or thirty pounds, he attempts to get it up by replenishing his fire, as it seriously needs it, with coal, which only tends for the time being to reduce the pressure still more until it has been capable of delivering its gases, ready for combustion. After this little explanation, the proprietor shook his head, and said he had never thought of it in that light and that he would have to call John to him and have a talk with him. Now the result of this was from that time on, the man's records never fluctuated in the same manner again, and the average steam line maintained was one which showed constant attention to firing frequently in small quantities, and keeping himself in shape to meet these emergencies. Undoubtedly, the man had to work a little harder at first, but afterwards, it was easier when he properly understood the matter and manipulated his fires accordingly. The suggestion from the proprietor was exceedingly valuable It resulted in the proprietor teaching his man, and in mutual regard between them afterwards, because it showed that the man was capable of being taught and also willing to be, and that the proprietor had evidence of the resulting fidelity. The dissemination of knowledge among firemen can certainly do no harm and when it reaches a man who desires to hold his position and give satisfaction, it will do much good. Men uneducated to the science of what contitutes firing steam boilers can hardly be expected to use that knowledge which others possess professionally. Some men will fill a furnace full of coal, so as to have more time to walk around; then after a time up goes the steam pressure, because more heat is generated than is wanted, then the feed water is turned on and the water level run up so as to keep the steam pressure down; the safety-valves may blow or not; the damper is closed; the fires smolder; large quantities of carbonic oxide gas go up the chimney, and this means an escape of unconsumed fuel, which means dollars and cents. After a while the fires burn lower, and down goes the steam, helped down, it may be, by another dose of coal, and so we can imagine the final effects on boilers used in such a manner. The position of a fireman may be considered an humble one by some folks, but he is a man for all that, and his pride in what he can do is a stronger spur than anything else. Let him see that you care for what he is doing, and take a careful interest in his work, and let him understand furthermore that his own grading depends upon himself, as established by his records; then you are in a fair way to have confidence in your man and in your safety, and also feel assured of economy of fuel. But eventually you must pay him what he is worth. If not, some one else will be glad to have him. Suppose, for instance, a man who burns three tons a day is paid two dollars for such service, and in so doing he is wasting as little as ten per cent. If coal cost $4.50 per ton, the loss will be $1.35 per day, or what is equivalent to paying a man $3.35 per day who can save this amount, but when amounts of say 8,000 tons per month are used, the saving of only ten per cent. amounts to $80 per day, and a small portion of which offered as a premium to the men who use this coal would go a long way towards saving the remainder of this money. What is wanted is the maximum of steam per dollar's worth of coal burned. Much can be saved by the manner of its use, and it is within limits furthermore to say that from five to ten per cent. is frequently gotten rid of by firemen not qualified as such and entirely ignorant or indifferent regarding the science of complete combustion. Certainly it is of vastly more importance to a proprietor, both on the score of safety and economy, that his fireman shall be a man trained in the art of properly burning the fuel supplied him than that his engineers shall know, particularly if the latter does not impart the information to the fireman. The practical value, therefore, of the steam record is in this connection that it compels the fireman to give close attention and maintain uniform water level; and uniform steam pressure cannot be had with anything short of the closest scrutiny of the steam gauge, which means economy of fuel and safety as well. The explanation of the charts has given much information touching unexpected occurrences, but innumerable other instances might be cited which would only tend to exhibit the surprisingly large number of them, possible wherever steam is used, and as these facts become more generally known to those who are not at present deriving the information from such instruments, there will be extended and more careful methods of caring for steam boilers under pressure inaugurated, ultimately resulting in not only greater economy of fuel, but in a greater degree of immunity from those disastrous explosions which destroy so many lives and so much property annually.

Dr. MOSES: I would to ask Mr. Church what is about the average size of independent engine that he would recommend.

Mr. CHURCH: I think the question is not governed by the size of the engine. I think it is governed by the size of the dynamo, and that in turn is governed by the nature of the circuits, which have to be laid out. You have got to discover what your distribution of light is to be, then adapt your dynamos to that, then adapt your engine to the dynamos. It is not a primary question. I should determine as far as possible what my minimum load was to be, make that my smallest unit, and after that bring all the subsequent units to the same power, or, if found better, to still larger units, as indicated in the diagram.

Mr. T. C. SMITH: Mr. Church's paper is limited to incandescent stations. The use of a small engine in arc stations has been very much condemned. In an arc station you know about what your light is going to be. If you know your load is going to be 500 horse-power you can start your engine at pretty nearly its full load. There the big engine is undoubtedly the more economical. But in an incandescent station there is no regularity as to the amount of load. We must keep that point clearly before us, that this discussion is limited exclusively to incandescent work. There are comparatively few incandescent stations that are running with shafting. Most of them are running with independent engines.

Mr. KERR: There is another thing that I wish to draw attention to. A great many men have a misconception of large versus small engines, as against subdivided versus non-subdivided power. Let us not talk about the difference between 60 horse engines and 100 horse engines, and whether it is better to have 60, or 75 or 125 horse-power. The thing is a broad matter and not limited to the size of the engine. It is subdivision versus non-subdivision.

Mr. J. M. SMITH drew attention to the value of compound engines, which were coming into extensive use abroad.

Mr. A. P. WRIGHT: I have recently taken charge of a station in New England where we are using large engines with counter-shafting. We are using somewhere near 5½ pounds of coal per horse-power per hour, which I attribute in a great measure to our want of subdivided power. Of course, there we have an extreme case. But it will not be an extreme case in the future. On Saturday night only do we have an ampère line that approaches anywhere near Mr. Church's illustration. On the ordinary week days the stores close at 6 o'clock, so that our highest ampère line is maintained for a short time only and then very rapidly falls.

Mr. KERR: Mr. Church's paper mentioned the difficulty of driving incandescent lamps from very slow speed engines on account of the fluctation from revolution to revolution. That is a thing which can be noticed in a great many places. There is another thing which goes hand in hand with that. It is quite a well-known fact that a slow-speed engine has comparatively small friction. This is generally acknowledged. Now put fly-wheel enough on a slow-speed engine so that it will not make the lamps flicker, and you will find that it has a very large friction. The reason that a slow-speed engine has small friction is because it has not fly-wheel enough, and the number of tons of fly-wheel to give it good regulation makes it a high friction engine. That is a thing which is very little thought of in electric lighting, and when thought of is only thought of too late. That applies not at all to high-speed engines.

Mr. S. E. BARTON then read a paper entitled:

THE RELATION OF ELECTRIC LIGHTING TO FIRE INSURANCE.

In considering the relation between electric light and fire insurance interests, I must confine myself mainly to the situation in New England, because I am familiar with what has been and what is now being done there, and I am quite as unfamiliar, except in a general way, with the relations that exist between the two interests outside of that small but lively quarter of our country.

In order that you who live away from New England may better understand what I may say as I proceed, it will be well for me to tell you briefly what kind of an insurance organization we have here.

The New England Insurance Exchange, which exercises a modest control over a part of the fire insurance matters within that territory (with the exception of the city of Boston and State of New Hampshire), is a body composed of the special agents, adjusters, traveling men or so-called "field men," representing the various stock fire insurance companies doing business there—some one hundred and fifty in number. These men mostly have their headquarters in Boston, which is verily a "Hub" in that respect. They are constantly skirmishing over the territory, individually or in squads of two or more, adjusting losses, and occasionally, through the co-operation of their local agents in the towns and cities, stealing good risks from each other or from some other competitor; but every Saturday finds a large majority of them back in Boston, where they convene in regular session and consider, with legislative dignity, any matter of common interest—electric lights included. They swap experiences, swap yarns, swap anything for something better; consequently they are a body of wonderful unanimity in any cause that promises common good to themselves and justice and fairness to others. They say to electric lights, "burn," after our inspector has approved the manner in which they are installed and maintained; and as a consequence there are in New England to-day, not including Boston and New Hampshire, 13,944 arc and 157,848 incandescent lamps radiating their beautiful bright light where the feeble flicker of the gas jet and kerosene lamp could not penetrate.

So concerted is the action of these men that were they by reason of any necessity compelled to say that electric lights shall not burn, comparative darkness would once more reign supreme in that fair land, but while they continue to count upon their fingers the yearly fires caused by this modern illuminant, I think I can safely assure you that their dreaded power of extinguishment will not be exercised. I have made exceptions of the city of Boston and State of New Hampshire, the reasons for which are these: The former, in its fire insurance matters, is supervised by a similar organization to ours, known as the "Boston Underwriters' Union," which handles electric lights in the same manner as our exchange. The latter, through antagonistic and unfair legislation over two years ago, caused the absolute retirement from that State of every outside stock fire insurance company, and they now manage that business themselves. By what light they work we know not, but judging from their sad experiences of the past year, we are led to believe that they work by the unholy light of their own wicked ways.

I have described the character of our exchange principally to show the difference between it and most of the insurance organization of our country, which are generally composed of officers of companies, or local or general agents in the large cities, between whom, by reason of their greater competitive relations, there exists a less amiable desire to harmoniously and successfully devise and carry out methods of improvement and mutual good. In the first year of our existence, some five years ago, we realized, after having paid considerable sums for losses caused by electric lights, that our interest demanded the inspection of all such apparatus by some person selected by ourselves if we were to continue granting permits for the lights without charge. We were a year or two, in a sort of experimental way, in getting settled down to a perfect system of inspection, but the result of the last two years immediately preceding 1887 showed us for the labor we had undertaken a loss of less than eight thousand dollars from electric lighting in our territory. We had by that time not only given up all thought of making an extra charge for a permit to use your lights, as we do in many cases for kerosene oil, and in some instances for gas, but we were fast beginning to show our preference for your illuminant by granting reductions in our rates of premium. The year 1887 has shown us a loss record from your lights something less than any previous year, notwithstanding the great increase in your installations, and the spirit of recognition of your superiority in point of safety has steadily gained ground, until I am happy to predict that before another month has passed the New England Insurance Exchange will have announced its favor in the form of a schedule of reduced rate, which it purposes to make on certain classes of risks where the exclusive use of electric lights is guaranteed.

I think that in this respect we will have fairly taken the lead.

A proposition to this end was made by the electric light committee of our exchange a year ago, but while we had for two years previous made an occasional reduction in rates, and have done so more generally during the past year, the time has not seemed ripe until now for an open announcement to that effect.

This feeling of preference for electric lights has been very gradual in gaining ground with us, and has reached a general recognition from the fact that the fires from that source have been few in number and the losses small

in amount, and this favorable result has most assuredly been due to our perfect system of inspection.

In this claim I am supported by the greatly increased number of fires that are reported as occurring in sections where insurance inspection does not prevail.

That there are in your method of lighting many inherent possibilities of causing combustion and loss of property thereby I need not claim, because none of you would for a moment deny it; but what I do claim, and mean to persist in maintaining, is that there is no reasonable excuse for any fire to be caused by your apparatus, except in very rare cases, where some unexpected and unavoidable accident may occur. It is quite possible for you to reduce the fire hazard of your system to the very lowest degree. It is quite *impossible* to do so with any other means of artificial lighting.

How can any care or control be exercised over the promiscuous use of kerosene lamps, while men, women and children are handling them? What can prevent the innocent but agile cat from upsetting the lamp, carelessly left in its path, as it is not infrequently accused of doing? Surely no insurance inspector, even with his ubiquitous habits, could prevent such catastrophes.

While greater care and a system of inspection could prevent many explosions in the gas system, they could not prevent combustible material from coming in contact with the open flame, neither in the dwelling, the store nor the workshop; nor could they prevent an accidental escape of gas through a leak or a burner carelessly left open, and in that event no amount of cautionary rules could deter the innocent occupants of the premises from going in search of the leak with an open light in their hands.

While our policies distinctly exclude damage caused by explosion, unless fire ensues, and then only cover the damage *by fire*, there is usually fire enough to "ring us in," and the drawing of the line between the explosion and the fire is usually disastrous to us.

Therefore I hold that, while no possible human foresight can prevent fires from the old methods of lighting, it is not only possible, but quite an easy matter, to prevent them in your case, if you set about it rightly.

If I were to presume to offer advice in the matter it would be this: Where insurance inspection is already being practiced, combine among yourselves and support it by paying whatever is reasonable for carrying on the work in an intelligent and economical manner; also by helping them improve their rules and requirements from time to time as your experience develops new means of safety.

Where such work is *not* being performed, get together in the same manner, those of you who are operating in that field, and ask the insurance men to appoint an inspector, then submit your work to him, conform cheerfully to his reasonable requirements, and go to the public with his approval. The approval by insurance companies of any lighting, heating or power device is *necessary*. The public *wants* light, heat and power, but it *must have* insurance, for on that the great commercial fabric of to-day depends for solidity.

By such inspection you will bring the fire hazard down to the minimum; you will largely increase the growing confidence of the public in your lights; you will rapidly clear away any lingering prejudice with insurance men against you, and in place of opposition that you may now occasionally meet with from them, you will readily obtain their fullest indorsement; more than that even, you will doubtless receive positive encouragement from them in the way of concessions in rates, in many cases.

The two interests should harmonize and work together to the greatest degree. You have in your system of artificial lighting great possibilities of reducing the enormous fire waste considerably, while we have, through our indorsement and encouragement, the power to largely increase your development; and the two together can give mankind more light and better light, and he needs it.

I do not hold that you are deficient in any degree as to what does and what does not insure safety in your work, but I think that you will agree that in the construction and maintenance of your equipment you are sometimes obliged to depend upon those who are not so proficient in their calling as they might be. The good insurance inspector, who gleans his knowledge and experience from all, helps you to educate and improve in usefulness those employed to whom you intrust your work. I refer particularly to the construction and dynamo men, and the trimmer, to the latter more particularly. If this functionary had possessed a knowledge of the possibilities of fire from the arc lamp, the losses from electric lighting in New England last year would have been too inconsiderable for mention.

Right here I wish to speak of the habit that sometimes possesses local companies; that of hiring inexperienced help because it is cheap. It is false economy, I think.

Competition, which is very great among you, drives you in some cases to lowering the standard of your material and work. It compels you to figure in every possible way to get a job. Nine of you may be honestly inclined to maintain the highest degree of perfection, but the tenth one outbids you all by figuring for cheap work. Careful and conscientious insurance inspection brings him up to the rack, or shuts him out, and we all profit thereby.

The question of insulation was referred to in in a pointed and timely manner by our friend Haskins, a year ago, and his suggestions seem to have taken root in the East. Insulated wire is now the rule, rather than the exception, in those places where insulation is most needed, and painted wire has "lost its grip." The difference in the cost is too slight, and in point of efficiency and economy too great, to allow the reform to languish.

The location of central stations seems to be receiving merited attention, but not to that extent which the good of the profession demands. In the past, the practice has been to secure power, especially in the smaller places, where it could be had the cheapest, without regard to permanency and surroundings. The result has been that you have gone into cramped quarters, with hazardous occupations on all sides, above and below you. You have got power by using boilers already being worked well up to the limit of safety, or you have set other boilers in the limited space at your disposal.

There have been fires and losses charged to you which you might have escaped by locating more wisely, and as a consequence too many insurance men now look upon the electric light station as one of the hazardous risks.

Locate by yourself as much as possible, build after modern fashions; do not spare brick walls and cement floors where they will add to your safety, and then you will get lower rates from stock fire insurance companies, or our mutual" friend, Woodbury, will provide for you.

There are in New England, as many of you are aware, a dozen or more good, strong mutual fire insurance companies, known as the "Manufacturers' Mutuals." They confine their acceptances of risks to the largest and best manufacturing properties in New England and the Middle States, and, to a limited extent, in the Southern States and Dominion of Canada. Mr. C. J. H. Woodbury is one of the vice-presidents of the largest of these mutual companies and the recognized expert authority for them all. About five hundred of the largest manufactories insured by them are lighted by electricity, either arc or incandescent, and very largely isolated plants. They have received the inspection of Mr. Woodbury, and the greater part of those in New England that of Inspector Brophy also. I take pleasure in quoting from a letter on the subject recently received by me from Mr. Woodbury. He says:

"When electric lighting was first introduced it was the cause of a great many fires, there having been twenty-three fires from this source in the sixty-one mills using it in 1881 and 1882. By April, 1882, all the electric lighting plants in property which was insured by the mutuals had been changed to conform to the rules for installation which I had prepared in December of the previous year, and since that time *we have not had a single fire from electric illumination I do not know of* any fires caused by electric lights which did not owe their origin to a disregard of principles laid down in these rules as essential for safety."

I think that statement bears me out in my assumption as to the almost entire immunity from fires due to artificial lighting that is attainable by the use of your methods, and I ask no better support.

Mr. Ridlon has advanced some excellent ideas looking to better work, in point of safety, in construction and maintenance—that of examination for fitness and qualification of the men who do this work, and the granting of certificates to them if found competent—the same as is done in the case of steam engineers. He would have the Board of Examiners composed of electrical and insurance experts. The absolutely impartial inspector is still needed to see that the "*tenth man*," of whom I have previously spoken, does not prosecute his nefarious work without a certificate: also to see that those *who hold certificates* are not intrusting their work to cheap men *who don't hold them*, or that the guileless trimmer is not falling into the habit of leaving the bottom off his arc lamps.

I would not occupy your time with technical suggestions, if, indeed, I had any to offer, because they had better be left to printed rules and inspectors; but it may interest you to know to what extent your business has prospered in New England.

The following figures are taken from our inspection record and are probably about right. They are *inclusive* of Boston but *exclusive* of New Hampshire. For comparative purposes, I give them as they stood at the beginning of 1886 and also 1882.

Number of Arc Light Central Stations.

	1886.	1888.
In Massachusetts	26	45
In Rhode Island	5	8
In Connecticut	9	21
In Maine	4	14
In Vermont	None	5
Totals	44	93

Increase of 1888 over 1886, 111 per cent.

Capacity of Above in Arc Lamps.

In Massachusetts (including 2,168 in Boston in 1886 and 2,475 in 1888)	3,693	7,305
In Rhode Island	831	1,961
In Connecticut	782	3,311
In Maine	520	1,465
In Vermont	None	415
Totals	5,826	14,457

Increase of 1888 over 1886, 148 per cent.

Number of Incandescent Lamps from Central Stations.

In Massachusetts (including 9,000 in Boston in 1888)	8,600	74,500
In Rhode Island	600	2,200
In Connecticut	None	11,050
In Maine	400	8,100
In Vermont	None	1,400
Totals	9,600	97,250

Increase of 1888 over 1886, 913 per cent.

Number of Arc Lamps in Isolated Plants.

In Massachusetts	459	721
In Rhode Island	416	731
In Connecticut	223	332
In Maine	10	50
In Vermont	58	128
Totals	1,166	1,962

Increase of 1888 over 1886, 68 per cent.

Number of Incandescent Lamps in Isolated Plants.

In Massachusetts	16,003	40,619
In Rhode Island	4,140	9,546
In Connecticut	2,117	11,050
In Maine	1,860	6,908
In Vermont	None	475
Totals	24,120	68,598

Increase, 1888 over 1886, 184 per cent.

Total arc lamps, 1886, 6,992: 1888, 16,419. Increase, 1888 over 1886, 134 per cent.

Total incandescent lamps, 1886, 33,720: 1888, 165,848. Increase, 1888 over 1886, 392 per cent.

Total arc and incandescent, 1886, 40,712; 1888, 182,267. Increase, 1888 over 1886, 348 per cent.

Those of you who know the ratio of increase in other sections of the country for the corresponding period, can judge if New England insurance supervision is a detriment to your business, or otherwise.

A whole year without any considerable fire loss in our country from electric lighting would be a splendid record, but none too good for any of us to contemplate.

While such a result is far outside the bounds of probability in the present condition of things, it is well inside the bounds of possibility. As well might we hope to revolve the earth from east to west as to hope for anything short of millions of dollars of fire loss annually from the old methods of illuminating by combustion—the candles, the gas and the kerosene oil flame and the accompanying friction match.

Mr. G. W. PARKER, of St. Louis, then read the following paper, entitled:

WHAT CONSTITUTES A GOOD CARBON POINT.

From the standpoint of the manufacturer all well baked carbons that are straight, free from cracks and other similar defects, and made from pure material, are good carbons.

The electric light engineer will say that no carbon is good unless it will centre properly and give him a reasonably long life with a good light. He is not at all inquisitive as to the method of its manufacture, provided it gives such results.

But as the manufacturer can go no further than to correct any errors in his mechanical processes, the value of the carbon afterwards depends upon the conditions of its use. Such carbons as are described in the first paragraph will with some currents be satisfactory, both as to light and life. In others, the light may be brilliant and the life too short, or there may be arcs too short or too long, flaming or other defects arising from the unsuitability of the carbon to the current, there being no inherent defect in the pencil itself. Therefore, to cover the whole ground of this important inquiry, we should also have the carefully compiled statements of your experience of the behavior of carbons burning in your lamps under varying circumstances. From this, results of great value to both sides might be obtained.

There appears to be no trouble in determining what constitutes a good carbon mechanically, but to you a good carbon means one that will give you satisfactory results in your use of it, and there we find several difficulties, without taking into account imperfections in your apparatus. The first is the difference in the strength of the current used in the different systems, and, also, in many cases in different plants of the same system, the corresponding differences in the resistance of each lamp, and frequently, unequal adjustments of lamps in the same plant.

For convenience we are in the habit of referring to those systems in which a small current and a long arc is used as high tension systems, and those in which a large current and short arc is used as low tension systems. The requirements of the low tension seems to be a carbon that is hard, well plated, and a good conductor, the latter being the most important. In the high tension, on the contrary, hardness and conductivity seem to be of secondary importance. There is a tendency to flame and burn unsteadily when a hard carbon is used in these systems, and a softer one sometimes becomes necessary, which in many cases shortens the time in which a lamp will burn without being re-trimmed, but in such cases the difference is fully made up in the brilliancy of the light. On the other hand, where a soft carbon is burned in a low tension current, the tendency is to form needle points which prevent the carbon from centring properly, causes them to heat and is apt to burn the holder.

Let us pursue the inquiry touching the questions of size, conductivity, mortality and light, and ascertain if definite relations can be established in regard to them that may result in guiding us in the selection of perfect carbons for use from a mass of mechanically good carbons.

Diameters.—It is a matter of great interest to know in what manner and to what extent the size of the carbon affects the result in a current of given strength covering, of course, in the general question of conductivity, the all-important results of light and life.

Hardness or Conductivity.—It is well known that a hard carbon offers less resistance to the current, or, in other words, has greater conductivity than a soft one; therefore, in carbons of the same length and diameter, made of the same material, by the same process, conductivity increases and diminishes repectively with their hardness and softness. In either hard or soft carbons, whatever conductivity they possess respectively, will be increased or diminished as their diameters or diminished, the length being maintained. It would appear, therefore, that it is possible to make a softer carbon of larger diameter that will be the equivalent, in conductivity, of a harder carbon of smaller diameter.

Mortality of Carbons.—Of carbons of the same *hardness* and length, but having different diameters, the larger will undoubtedly, outlive the smaller. Of carbons of the same *diameter* and length, but differing in hardness, the harder will outlive the softer. Therefore, a carbon of larger diameter, which is soft, may be equivalent to a smaller carbon which is hard, as to life, just as it has been shown to be equivalent in conductivity. The life of a carbon is, of course, dependent upon many vicissitudes, such as high winds, broken globes, etc.; but under the same conditions the statement made above is, undoubtedly, a fact.

Brilliancy of Light.—It is well known and admitted that as between hard and soft carbons of the same diameter the latter will give a more brilliant light. It is just as well known that in case of hard carbons those of smaller diameter will, within certain limits, give a more brilliant light than those of a larger diameter. On the above statement of facts it may be regarded as settled then that with the same diameter, but differing in hardness, the hard carbon will possess greater conductivity and have a longer life, but with less brilliancy of light; while the softer carbon will have less conductivity and a shorter life, with a more brilliant light. And, further, that with uniform hardness, but differing in diameter, the larger diameter will have the greater conductivity and longer life, with a less brilliant light; while the smaller diameter will have less conductivity and a shorter life, with a more brilliant light.

The foregoing statements indicate invariably that with greater conductivity light diminishes and life increases: and, conversely, that with diminished conductivity the brilliancy of the light is increased and the life shortened. In corroboration of this it appears that a small, hard carbon is, practically, the equivalent of a larger, soft carbon, their conductivity being also equivalent.

Heretofore, it has been considered probable that the diameter, candle-power, resistance per lamp, conductivity of the carbon point and strength of current, are all interdependent and a change in any of them will affect all the others, requiring a counteracting change or adjustment in some of them, in order to restore the proper relations between them. This, if so, you can readily see is difficult to do, for part of the work is to be done by the manufacturer, and the remainder is under your control.

On the other hand, if the deduction can be properly made from the statements herein presented, that the resistance of the carbon point will determine its capability in respect to light and life in the different currents, the trouble is practically removed. It is not impossible, I think, to construct a machine that will, at no great increase of cost, assort the carbons into groups of uniform resistance or conductivity. Then, with constant currents, clean lamps, perfect connections and insulation you will ascertain practically that carbons mechanically good will prove to be good and uniformly so in actual service.

Much more could be written upon this interesting question, but this paper is already too long. I have noted for your discussion some important points which I hope your experience will enable you to determine definitely if they are well taken or not. I would be glad to have the whole question of the imperfect burning of carbon points thoroughly canvassed, so that manufacturers would get some hints as to what may be done by them in the way of correction when the fault lies at their door. It is especially desirable to be informed if that very disagreeable feature in the burning of carbons called "flaming" is always the effect of one particular cause and what that cause is.

Discussion of this paper was postponed to the following day.

The meeting then adjourned till 9:30 of the following day.

THURSDAY SESSION.

The Association met at 10 A. M., pursuant to adjournment.

The PRESIDENT: The first business is, by special order, the amendment to the constitution, which the secretary will read.

RESOLVED, that Article IV. of the constitution be hereby amended to read as follows:

The president and vice-president shall be elected by ballot to serve during the following meeting.

The treasurer and secretary, who may be one and the same person, shall be nominated by the president, subject to the approval of the Executive Committee.

The Executive Committee shall be chosen by ballot at each meeting, either annual, semi-annual or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

Discussion of the subject was ruled out of order.

Mr. T. C. SMITH announced to the convention that arrangements had been made with the officers of the Philadelphia Gas Company, through Mr. Westinghouse, to have their stand pipe at Thirty-sixth street lit at seven o'clock that evening.

The following paper was then read by Mr. T. C. Smith:

THE DISTRIBUTION OF ELECTRICITY BY ALTERNATE CURRENTS.

The distribution of electricity by means of alternating currents, though comparatively new in this country, has already reached such an enormous importance that it is with great hesitation that I venture to speak upon it, even though limiting myself to the strictly practical side of the work, dealing only with the apparatus as we receive it from the hands of the manufacturer, and leaving out entirely the question of the efficiency of dynamos and converters. It is only the knowledge that the mistakes of those who enter upon any new line of business are the rounds of the ladder by which we all attain success that emboldens me to lay before you some of the conclusions at which I have arrived after several years' experience of varied types of electric lighting, both by the arc, by the direct current incandescent, and the alternate current incandescent.

The subject naturally divides itself into several heads, but I would first say that it appears impossible to lay down any general plan of distribution which shall be practicable in all cases. In almost every town a different plan will be required, and this will depend in most cases purely upon local circumstances. Systems and methods that would be admirable for thickly settled and densely populated districts will not be successful in thinly populated and widely scattered ones. I wish it to be understood that whenever I speak in this paper of success and successful systems, I mean successful entirely in a commercial way, and the conditions of this commercial success will vary in every town and district. I will, therefore, content myself with describing the method which I have found to be most successful in the various districts with which I have had actual experience, and leave it for those who may be called on to design and lay out the lighting of any particular district to judge for themselves which line of action to pursue.

Naturally the first part of my subject is the dynamo and the station detail. I have tried the small and large dynamo, and have concluded that it is a very great point to properly proportion the unit size of dynamo to the probable size of the station; that is, not to have dynamos of different sizes, but first determine that the unit shall be, making it as large as possible, and then make your whole apparatus additions to that unit size. This simplifies matters very much, enabling machines to be interchangeable, both as regards their parts and their work, and this I am sure will be admitted by all who have ever had the annoyance of a breakdown on engine or machinery, when perhaps they had standing idle plenty of apparatus which, from various circumstances, could neither be used itself nor be robbed to repair the breakdown.

I would drive each dynamo by a separate engine, and this for several reasons; by proportioning the engine to the dynamo, it will be possible to have the engine running slightly overloaded when the dynamo is doing its utmost during the hours of heavy lighting, and as this extreme load falls off to the lighter hours of running, the engine will be working at its point of best economy, instead of running underloaded, and thereby wasting steam. Thus we use in our station on Virgin Alley dynamos of 2,500 lights capacity each, driven by 200 horse-power engines. During 16 hours of the day these dynamos run driving 2,000 lights, and the engines are cutting off at quarter stroke, and developing 200 horse-power. During the other 8 hours, we have driven these dynamos as high as 2,800 lights, during which time the engine was of course overloaded and not working to so good an economy, but 8 hours of overload is not nearly so wasteful as 16 hours of underload. Again, we have had it very forcibly demonstrated more than once that if the engine be only large enough to drive the dynamo with ease, a heavy short circuit on the mains outside will simply pull the engine up or slow it down, without destroying the dynamo, and only those who have seen a 9-foot fly-wheel running at 250 revolutions per minute on a 200 h. p. engine, slowed right down in almost an instant of time, can realize the terrific strain to which everything is subjected in such cases, and I would mention right here that the element of time is a very great factor in such circumstances, as in an accident of this kind mischief is often done before the safety catches can melt out. The direct belting of the engine to the dynamo is always to be preferred; shafting is, except under exceptional circumstances, simply a nuisance for incandescent electric light stations, and the economy of one large engine over many small ones has been enormously overrated. For arc light work, where the lights are all lit and extinguished at certain hours, the large engine is good; but for incandescent work, where the load is absolutely out of the control of the station, it is impossible to steadily run a large engine at anything like its most economical load, whereas with separate engines the machines can be started and stopped the moment that they are needed or are done with, while the oil from shafting will always cause more or less grease and dirt.

For central station use, except for very small plants, I should certainly use separately excited dynamos, and should do the exciting from two or more dynamos, each capable of exciting the whole system. In this way, with the station running at its normal, the only regulation required is that obtainable by working the single rheostat in the field of the exciter, and as we have designed our station at Pittsburgh, this will mean the regulation of 15,000 lights by one six inch hand wheel. Of course each dynamo should have its separate field rheostat to make up for any slight difference in speed of engines. The two exciters should be so arranged that they can be run together or separate, or that either can do the whole work which, of course, is easily accomplished by feeding them into a separate pair of exciter bars on the switch-board, and charging the fields of the alternating dynamos from these. The general question as to whether it is better to use separate circuits for separate machines, or to couple them into a general set of 'bus wires and distribute from them, is too large to be lightly decided, as also is the question as to whether it is best to run separate circuits or separate districts, or to run into a general system of high pressure mains outside of the station, feeding into these mains at different points, and again distributing from them, and I am not prepared to express any preference, but think that local circumstances will generally decide this question. There seems to be no little doubt that in underground systems the network of high pressure mains would be the best, but for overhead work we have adopted the system of separate circuits from separate dynamos, using a switch-board which enables us practically to run any circuit or any number of circuits from any dynamo, and running these dynamos separately and not in multiple arc. In spite of the utmost precautions, the unregenerate telephone and telegraph men are always hauling wires across our high pressure mains and feeders, and while their wires and not ours generally suffer, after hearing the frightful roar that comes from the dynamo which is running the particular circuit so crossed, we always feel relieved to know that only one dynamo is in danger of being thrown out by the slipping off of the belt, and a twenty inch belt is not a pleasant thing to have flying around loose. In case of any trouble, such as fire, circuit broken down, or anything of that sort, we can pull the switch of that particular circuit until we can cut out the part affected. The system that I have laid out for use here will, of course, take a long time to introduce, in view of the fact that we are changing from one system to the other, and have to be governed largely by the location of our lighting, our existing lines, and the possibility of putting up additional pole lines, but it takes in my vision the form of a series of heavy mains down the main streets, with cross lines on the cross streets, with switches on the poles enabling any of the cross streets to be run from the mains on either of the main streets, so that in case of a fire on one of the main streets, the section represented by the block in which the fire occurs can, by the pulling of two switches, be completely cut off, while the cross streets on either side of the section will enable the lights beyond the fire or broken circuit to be operated with only the trouble of a slightly larger percentage of loss and the consequent dimming of the lights.

For the main overhead wires, I must harp upon the old string, which cannot be struck too often, namely, high insulation. For 100 volt current work, the old stand-by of "undertakers" wire will pass; but when it comes to 1,000 volts difference of potential, and 130 or 140 ampères to back it up, one realizes very quickly that nothing is too good to curb this fiery steed. We are still paying the penalty of early ignorance in having many circuits of underwriters' wire stretched upon our poles, and I have stood and listened with fear and trembling to the noise of a new dynamo which had only been in operation for a few hours, when we had four short circuits in as many minutes, caused by dead wires falling across these mains on a wet day; while, on the other hand, I have been gratified beyond expression to see our linemen remove ten or twelve old bare iron "district-call" wires which had been hanging all night right across our high pressure, high insulation mains, and this during a soaking rain. Especially should the service wires to the converters be of the best insulation, not only for fire, but for protection to life, for while the shock does not kill, even a 100 volt shock may make a man start so as to fall off a ladder, and any death or injury will be credited to the electric current. We have adopted a standard of a separation of three feet between the two wires nearest each other on our cross arms, and do not allow under any circumstances the tapping of service lines directly to these wires. All service must be attached through the medium of a small spreader on the end of the cross-arm, which I have no doubt all those present have noticed on the streets.

In some districts, where the number of lights in each building is small, we run secondary low pressure mains, and place the converters on the poles, and make our distribution from our secondary mains, but our experience has been that this is not a very satisfactory way of doing The percentage of loss on these secondary mains, unless the wires are very large or the converters very numerous, either of which is objectionable, causes such a decided variation in the lights as to give ground for numerous complaints.

The question of the loss on the high pressure feeders and mains is one which I think has not received enough attention. When the alternating system was first introduced, so much was said about the extreme smallness of the wire required that a great many of the arc light fiends throughout the country who had been accustomed to congratulate themselves on the fact that No. 6 wire was big enough for a 20 mile circuit, immediately jumped to the conclusion that because it was a high tension current, No. 6 wire was big enough for all cases; and consequently more than one case of dreadful grief has arisen. I have laid out our circuits on a certain fixed plan, which is that each circuit shall be laid out for 1,300 lights (that being the size of the unit which we at first adopted), and made of such sizes as to carry these 1,300 lights with a loss of not more than two per cent. with the whole load on. By having feeders large enough for this, we prevent any noticeable difference in candle-power from one end of the circuit to the other, and should we be even compelled to run a light circuit and a loaded one on the same machine, the increase in the one or the decrease in the other would not be injurious. Of course we try to so arrange our circuits that the load shall vary about the same on each, but the suddenness with which storms creep up in Pittsburgh makes our load very uncertain and erratic. We have run for three days and nights with only a little more than half of the machinery in operation, and then from Monday night to Friday morning have had to run every incandescent machine in the station under a load that fairly staggered it.

I now come to the question of the placing of the converters, and for this I think that you may safely lay down the general rule that wherever you are simply carrying current do it at high pressure and keep your low pressure for the purely local distribution. With proper precautions I do not see that there is any real danger in carrying the high pressure wires into and through the building. If a thousand volt current from a central station is not to be allowed in a building on account of its dangers, then every arc light plant—whether from central station or an isolated plant in the building—must be condemned for the same reason. Of course the cases where two wires of an arc circuit with a difference of potential of 1,000 volts are run close together are not nearly so many as must be the case where there is a constant difference of potential of 1,000 volts in the alternating system, and again of course we have the fact that the direct current on arc circuits is generally not more than 20 ampères, while, as I have remarked before, our alternating circuits run as high as 130 ampères; but the fact that one is a direct and the other an alternating current largely makes up for this difference. With all due respect for the many gentlemen who have discussed so learnedly on the deadly alternating current, and on the frightful results therefrom, and whose experience with the alternating system is mostly confined to the magneto bell or induction coil, I must maintain that the alternating current, while it is in mild doses of from one hundred to two or three hundred volts intensely more disagreeable than the direct current of the same voltage, when it comes to 1,000 volts or more it is very much less dangerous to life. I make this statement with the more confidence that I have tried them both, and we have in our station here not one, but half a dozen cases where our linemen and dynamo men have received the full 1,000 volts, generally being pretty badly burned at the point of contact, but experiencing no ill after effects, while whenever any of our men receive a shock from one of our arc machines, they are nearly always sick for a day after. This very fact of the alternating current being more disagreeable adds to its safety, as the men are disinclined to work on the wires, even when there is only a slight leak, where with the direct current they will often take much greater risks. In carrying our high-pressure wires through the buildings, we have adopted the invariable rule that they must be carried on porcelain insulators, and the wires themselves waterproof in all cases. We do not allow them to be run in molding, but where the wires are to be concealed or protected a casing is run around the wires, outside of the porcelain insulator, giving them a perfect air insulation, and hard rubber must always be used for floors and walls.

The converters are all placed with porcelain knobs behind them, giving an air space of two inches between them and the wall, and we prefer in all cases to put them against brick rather than against wood or plaster. I understand that in some districts the use of converters inside buildings has been forbidden, but I think that this position is a most unjust and untenable one. The only argument that can be brought against their being placed inside is the danger to life or of fire. For the first, the converter is well insulated, and is placed high up out of reach, and, most potent argument, though one I am sorry to say often refused recognition, it is not placed there to be handled. As regards the danger from fire, all the converters with which I have had any experience are boxed up completely in iron cases, the only opening in which is a small one at the bottom for ventilation. They cannot possibly get hotter than the melting point of lead for the simple reason that if they should the fuses would blow out and cut them out of the circuit, and any one who has performed the old experiment of melting lead in a piece of paper can easily see that this heat is not liable to set any thing on fire, and even should the converter burn out no flame can escape from it to set fire to anything, however inflammable. If the converter is to be banished from buildings on account of danger from fire, then every stove, high pressure steam pipe, and for that matter every gas jet, must also be banished.

In a Chinese fire-cracker lately published, I find the statement that Inspector McDevitt has relegated to the cellar all converters, and that he says that in the first case of explosion or fire from them they will have to go to the street. Now, as Vice-President of the company owning these converters, I have simply to say that this is not so, and that the converters are placed all through the buildings, wherever we may desire to have them, and only three or four are in cellars. Moreover, so far from Mr. McDevitt making any such statement, he has steadily refused even under the most urgent solicitation of the Chinese gentlemen, to make any such restriction, but has very properly stated that until an explosion or fire occurred, he can take no such action. I speak of the publication as a "fire-cracker" for three reasons: First, because it is red; second, it is chiefly noise; thirdly, a good many crackers are only fizzles.

As regards the liability to burn out and the dangers therefrom, I can only say that from over 600 converters of all sizes, from 5 to 50 lights each, in an experience extending over twelve months of constant service, night and day, without any stop, we have had but three actual cases of burning out, two of these being 5-light converters and one being a 50-light converter. The two 5-light converters were simply slowly roasted out from overloading, until finally the insulation on the primaries was charred through, when the fuses blew out instantly and all was over. In one case the customer had been attracted by the converter singing, and was standing looking at it when his lights suddenly went out, and he had to go into a neighbor's store to know whether the trouble was in his lights only, or with the main current. The 50-light converter suffered in the same way, having nobly endeavored for some two days to run 130 lights. It was one of three on a section of secondary mains, and the linemen who had been sent out to examine them, owing

to complaint to us of poor light, reported that two of them were all right, as they were cold, but that one of them was bad, as it was very hot, and preparations were being made to change this converter when a message was received from one of our customers that the "stove on the pole" in front of his place was smoking.

Investigation showed that both plugs in the other two converters were blown, and the only reason that this one had not followed suit was the fact that some ingenious gentleman had made them of copper. We have had three cases of defective converters; that is, converters with a wire broken inside, or short-circuited, so that the moment the current was put into them they would blow out all the fuses, and if new fuses were put in they would again immediately blow, but the men in these cases of course immediately returned them to the shop for examination; that is to say, out of 600 converters, we have actually had to remove or repair one per cent. in actual service, and I submit that on a total converter capacity of 17,000 lights, this is a very good proof that these converters are well made and not dangerous.

In all of our experience, we have not had one single case of connection between the primary and secondary, or the primary and the shell of the converter, even in the case of the burned-out converters, and we had just a few days ago the first case of a connection between the secondary and the shell of the converter, and this last was found upon examination.

We started in with the idea that it was better in cases where we had from the number of the lights in a building to use more than one converter to bank them; that is to say, connect all the primaries and all the secondaries in multiple, and distribute from this one wire; but two or three peculiar experiences have led us to change our plans, and never to do so if it can be easily avoided. We had two or three unfortunate cases where one converter of a bank for some unknown reason would blow its plugs, thus overloading the others, then perhaps another would give way, and thereafter it was a race as to which would blow its plugs the quickest. It is not calculated to make one feel comfortable to have 400 lights in a theatre go out at once, just as the curtain was about four feet from the stage, in the beginning of the third act; yet this was our experience last Christmas day. We had the converters fused up and running in half an hour, but next day the same thing occurred, though the gas man seeing the lights dim down was quick enough in shutting off his different circuits to stop three or four converters, which gave him lights enough to pull through. We have cut this building up, and each converter now carries its own load,

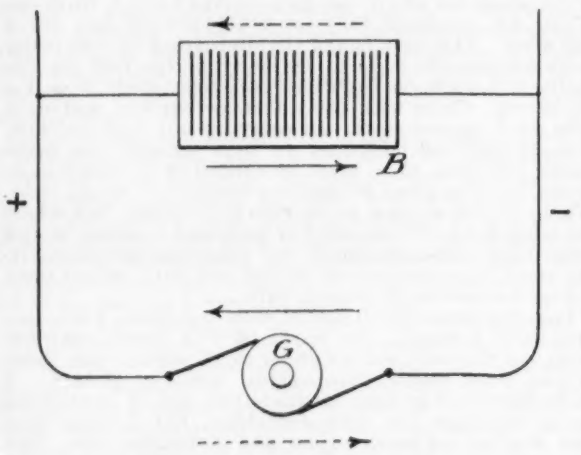


FIG. 1.—THE ENERGY OF ALTERNATING CURRENTS.

with the result of our detecting one of them which for some reason unknown always tried to do more than its share of the work, but while we have marked it, we have not troubled to change it, as, working singly, it does its work well. We have had another case of the same kind in another bank of converters, which have also since been cut apart, when we found the trouble arose from a poor connection which heated up the fuse to melting point; yet, as we have in the City Hall two banks of 12-40 light converters each, and in the Union station a bank of 23-40 light converters and 3-20 light converters, which have never had the current off them for nearly three months, and have never had a single converter of all these blow its fuses, we cannot say that this result would always or even generally obtain; but as the object of banking is primarily to prevent the total extinction in case of one converter going out, and this is better attained by the judicious running of the secondary circuits, we prefer keeping the converters separated.

For the secondary wiring in the buildings, we need lay down no laws. The rules governing this are too well known to need any repetition. One advantage of the alternating system, which was first brought to my attention by one of our wiremen, is the fact that wires carrying the alternating system do not blacken the surface on which they run. We have in our station circuits of direct and alternating currents side by side, put up at the same time on a ceiling painted in very light colors, and which have been burning the same number of hours. The paint under the direct current wires is very dirty, in the usual style, and the wires themselves are covered with a black deposit, while the alternating current wires, and the ceiling on which they lie, are as clean as the day they were put up.

There yet remains one point on which I wish to say a few words, and it is a subject of the greatest importance. Now that the alternating current distribution is a pronounced success, there is no reason why the places of all others where incandescent light is most desirable, namely in residences, should not enjoy the advantages and improvements from which they have hitherto been debarred by their distance from the usual centre of distribution, and it is when we bring electricity into the dwelling-house, where it will be daily and hourly needed and handled by women and children, that we realize how absolutely necessary it is that we use anything and everything which can tend to make safe its introduction and manipulation.

Of course, the first, second and third necessities are: Good insulation, better insulation, and best insulation; but besides this there are other points to be considered, and one that seems to be worthy of very careful consideration and the fullest discussion is that which has been more than once suggested, namely, the making of a permanent ground connection with the secondary wires. The object of this, of course, is that should a leak occur at any point between the primary and the secondary, the current being already grounded will render it impossible for any one to receive a shock by touching the secondary, and at the same time making an earth connection. When I first considered this question, I said in my haste that this was not a proper course of action, as one is simply provoking a ground at some other point, and seeing the careful insulation of the converters we use, I could not see any danger of a leak across; but I have since made up my mind not to come to

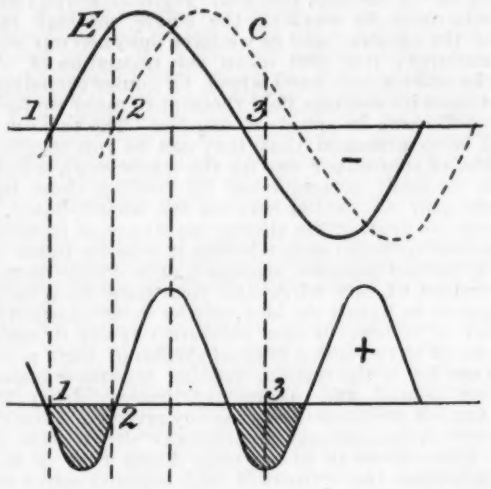


FIG. 2.—THE ENERGY OF ALTERNATING CURRENTS.

any conclusion at all until I have considered and heard some discussion, both pro and con, and for this purpose I should like to hear the most bitter partisans on either side, that we may get from them every little weakness on either side of the question brought out.

In a paper like this, it is impossible to do more than to give the merest sketch of the subject, but I trust that what I have said may be the means of inviting discussion and inquiry, for it is only by this means that we can arrive at the true facts of any case, and, as we all know, the electric light industry has suffered more than tongue can tell from the general ignorance of its dangers and requirements, which hindered and injured its early introduction into this country, which led to the spending of so much good money on plants and wires which were not merely insufficient but absolutely dangerous.

From that we have taken as it were a new departure, and entered upon a new era of progress. Let us not fall into the same errors which marred the early history of our business, but strive with might and main, by discussion and interchange of experience, to make each new installation another stride towards perfection in what I think is undoubtedly the greatest achievement of the age,—the distribution of electricity by alternate currents.

This was followed by Mr. O. B. Shallenberger's paper on

THE ENERGY OF ALTERNATING CURRENTS.

The adoption of the alternating current for electric lighting has introduced a number of questions in regard to its measurement which have an important practical bearing, since they involve the subject of the relative efficiency of the direct and alternating systems; and, for this

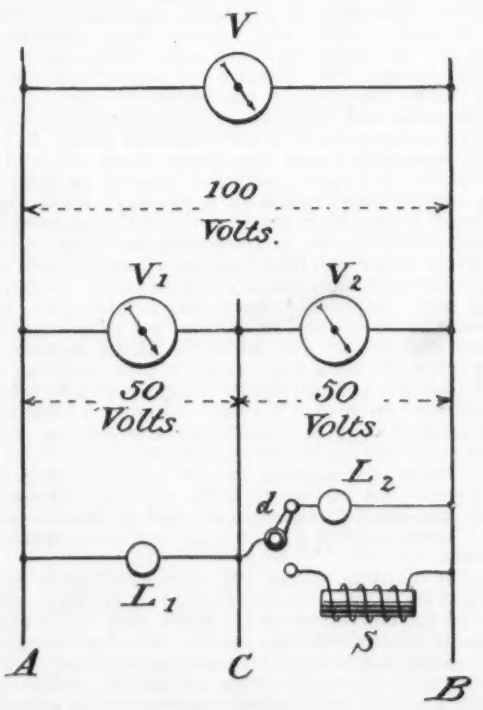


FIG. 3.—THE ENERGY OF ALTERNATING CURRENTS.

reason, perhaps, a few words on the subject may not be amiss.

It is not proposed to enter into a mathematical discussion, but rather to offer a few illustrations and examples which will assist in a general understanding of the subject, and at the same time prove the uncertainty of the well known rules for direct currents, when generally applied to alternating currents. Under certain well defined conditions such methods may be employed without sensible error, and, fortunately for the electric lighting industry, these conditions are naturally present in the exact kind of apparatus necessary for the simple and economical distribution of the alternating current.

In estimating the amount of energy expended in a circuit traversed by a direct or continuous current we are accustomed to base the calculation on measurements of the difference of potential between the two points of the circuit in question, and at the same time the current traversing that circuit. The product of these two quantities, as is well known, gives a correct measure of the energy of the circuit expressed in watts. This method may or may not be applicable to alternating currents, the distinction depending upon the presence or absence of self induction in the circuit. In the case of a straight copper wire going out from the source of current and turned back on itself in close proximity, it may be assumed that self induction is practically absent, and hence no sensible error would be involved in taking the product of the difference of potential between any two points, as measured on a Cardew volt meter, and the current traversing that portion of the circuit as determined by a Siemens dynamometer, and then using these two factors in the product which represents the amount of work done. This would give a correct result; but the introduction of a coil of wire wound in one direction, especially when it surrounds an iron core, greatly modifies the conditions, and causes an error, the amount of which is dependent on the form and size of the coil. The reason for this is that the additional element of self induction has been introduced, with consequent retardation of the phases of current. This simply means that, as the difference of potential alternately rises and falls and reverses its polarity, the corresponding fluctuations of current do not occur at corresponding instants of time. The want of synchronism may be of any amount between zero and one-quarter of a complete wave length. When there is no self induction present in the circuit, there is no displacement, but a departure from this relative position may be produced by introducing self induction into the circuit, and to a point which may theoretically cause the waves of the current to lag a quarter of one complete alternation behind the wave of the electromotive force, although it is impossible to realize this amount in practice.

Let us inquire now what is the effect of this displacement on the amount of energy expended in the circuit. But as a preliminary step it will be well to examine the case of a secondary battery which is being charged from a suitable direct current generator. Suppose first, that current is supplied from the generator with a sufficient electromotive force to overcome the counter electromotive force of the cells and produce a certain flow of current. We may introduce into the circuit a suitable ammeter to determine its amount, and connect across the circuit a voltmeter, and by the product of the indications

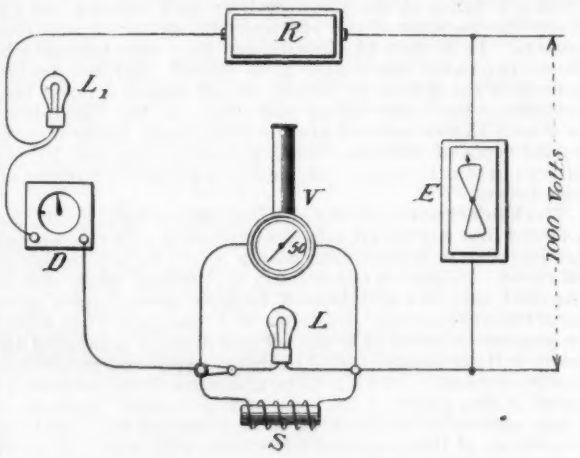


FIG. 4.—THE ENERGY OF ALTERNATING CURRENTS.

of these two instruments we obtain a result which shows the expenditure of energy at that time. But if, later, in the process of charging, the speed of the generator is reduced to such a point that the counter electromotive force of the battery is sufficient to overcome the electromotive force of the generator and cause a flow of current in the opposite direction, it is well understood that the battery would no longer be charging, but would be running the dynamo as a motor and consequently expending energy upon it. If the resistances of the armature and battery are low, the readings of the voltmeter and the ammeter might be exactly the same as in the former case, and the product of these two factors would of course show the same amount of work done. In the absence of any other information than the readings of these instruments, it would be impossible to judge whether work was being done by the generator on the battery or by the battery on the generator.

Another element requires consideration, and that is the direction of the current as related to the difference of potential across the circuit. Referring to the diagram, Fig. 1, a generator is shown at *G* supplying current to charge a battery *B*. Let it be assumed that the electromotive force of the generator is in such a direction as to make the one conductor positive, with relation to the other. Calling this a positive electro motive force, a current in the direction of the full arrow would be positive, and one in the direction of the dotted arrow would be negative. Whenever the generator is doing work on the battery the current flows from the positive to the negative conductor through the battery, or in the direction in which the generator tends to deliver the current. If we had called the electro motive force of the generator negative, this would be a negative current. We can assume either, but in each case the current and electromotive force have the same sign. When, however, the electromotive force of the generator falls sufficiently to allow that of the battery to overcome it and send a current in the opposite direction, as shown by the dotted arrow, the conditions are reversed; that is, the battery is doing work on the generator and driving it as a motor, but without the polarity of the external circuit being changed. We now have a positive electromotive force, a negative current in the battery, and work done by the battery on the rest of the circuit.

The foregoing is only an illustration of the general law that when the difference of potential between two points on an electrical circuit is of the same sign as the current traversing it, work is being expended on that portion of the circuit; and conversely, if they are of opposite signs, work is being restored by that part of the circuit. It is, therefore, necessary to know the relative polarities of the current and electromotive force as well as their amounts,

in order to have a complete knowledge of the energy of a circuit. The same thing is true of an alternating current; that is, we must know whether the instantaneous values of electromotive force and current have the same sign, as well as the values themselves, and this can only be the case where no self induction is present, or in the practically equivalent case, in which the self induction is so nearly neutralized as to be of no relative importance.

Referring now to Fig. 2, there are shown two curves in the upper figure, E and C. E represents the phase of electromotive force of an alternating generator, and C the corresponding current through a circuit possessing a certain amount of self induction. Distances along the horizontal line are taken, as usual, to represent successive periods of time, and the relative amounts of current or electromotive force are represented by the vertical distance above or below this line, those above being called positive, and those below negative. It will be seen on inspection of the figure that at the instant shown at 1, the electromotive force is zero, while at the same time the current has a considerable negative value. Again, at the point 2 the current falls to zero, while the electromotive force has risen to the amount shown by the vertical line at 2. At 3 we have an instant at which the current and electromotive force are of opposite sign. Here we have three distinct cases, in the first two of which no work is being done, and in the third work is being done by the circuit on the generator; but in each case an effect would be produced on the instruments used for the measurements of electromotive force and current. In fact, taking independent continuous measurements of the electromotive force and current, it is quite evident that the same results would be obtained without regard to the time relation of the phases, so long as the form of each remained unchanged; and for this reason the result would be the same from such measurements whether the curves were coincident in time and the current curve occupied the same space as the curve E, or were displaced as shown in the diagram. In the former case, as there is no displacement of phase, the products of the current and electromotive force at each instant would be positive; that is, work would be done at each instant upon the external circuit except when passing through the values of zero.

The effect of the displacement of the current phase is shown in the lower figure, where a curve is drawn to show the phase of work done at each instant of time when the lag of the current phase is of the amount here represented. At the instant, 1, no work is being done, since the product of E and C contains a zero factor. Between 1 and 2 we have work done by the coil, since the electromotive force is positive at the same time that the current is negative. Then we have a period in which work is expended by the generator; and then at 3 again, work is restored by the circuit to the generator. By still further displacing the current phase the amount of work restored to the generator may be greatly increased. The example I have taken, a retardation of about one-sixth of the phase length, is a very moderate one, and easily realized in practice, and yet the amount of energy restored to the circuit in the work done by the coil is nearly one-fourth of the apparent amount of energy expended, as shown by the product of current and electromotive force. The diagrams are not intended to show the exact forms of current phase, or of the phase work done, but they are sufficiently near average conditions for the purpose of illustration.

A retardation of one-fifth of the phase restores about one-third of the apparent energy to the circuit, and beyond this point the proportion restored increases in a high ratio.

The actual work done can never be more than the product of current and electromotive force, and may easily be only a small fraction of that amount.

To show that this retardation is not an imaginary thing, but may have a very decided influence on actual measurements, I will describe two experiments which show phenomena that can be accounted for in no other way; or at least cannot be explained by the ordinary rules of direct current measurement. An experiment by the writer similar to the second of those described by Mr. Stanley in a paper before the American Institute of Electrical Engineers some weeks ago, is still another example of the same phenomena.

In Fig. 3 two conductors, A and B, are shown, between which an alternating difference of potential of 100 volts is maintained, and indicated on the Cardew voltmeter V. Between these two conductors a third C is placed, and two Cardew voltmeters V and V_2 are connected across the two circuits, and show by the sum of their reading the difference of potential between A and B. They should, under ordinary conditions, agree with the reading of the one at V. Between A and C is connected an incandescent lamp L, and between C and B, through a switch, d, the circuit may be closed either through the lamp L_2 or through a coil of wire S, which surrounds a soft iron core. With the connections as shown in the diagram, that is, with the switch connected to the lamp L_2, a perfect balance is obtained, and by adjusting the difference of a potential between A and B to 100 volts, we obtain readings of 50 volts on each of the voltmeters V_1 and V_2. If, however, the switch be transferred to the point which connects it with the coil S, a somewhat remarkable effect is observed. The readings of the voltmeters at V and V_1 remain constant, since the coil has been so proportioned by trial as to exactly replace the lamp L_2 and maintain L_1 at exactly the same degree of luminosity; but the voltmeter, V_2, instead of remaining constant in its indication, as might have been supposed, increases its indication to 80 volts, so that we have our choice, so to speak, of two measures of the difference of potential between the conductors A and B. These are of such large cross-section as to be of sensibly the same difference of potential throughout their length. Measuring at V we have 100 volts as before, but at V_1 and V_2 we have the sum of 50 and 80, or 130 volts. It is quite evident that there is some condition present entirely remote from any which could be produced by the action of a direct current; for it is absurd to suppose that at the same instant of time we can have two separate values for the difference of potential between the two points. The natural inference seems to be that these measurements show in reality only the average of effects which occur successively, although they appear to be simultaneous.

When an impulse from the generator occurs, current flows through V_1, and V_2 instantaneously, and this would give a reading of 50 volts on each, if acting alone; but the same impulse, acting through the coil S, produces a current which, owing to the self-induction of the coil, lags behind the electromotive force, and, therefore, the coil must restore work to the circuit at some point in the phase. This work is partly expended in the voltmeter connected to the coil, and for this reason it gives a higher reading than the other.

Fig. 4 shows a second arrangement in which the current is indicated by a Siemens electro-dynamometer D, and the differences of potential is maintained constant by means of the electrometer E. The current may be adjusted to the proper amount by means of the resistance R introduced in the circuit. An incandescent lamp L_1 is also placed in the circuit in series with the dynamometer, to indicate to the eye any fluctuations in the current. At L a similar lamp is placed, and around its terminals is shunted a properly proportioned coil S surrounding an iron core. A Cardew voltmeter V is connected at the same points to show the difference of potential. With the switch d closed, the normal current passes through the lamp L, and a difference of potential of 50 volts is shown on the voltmeter V. The dynamometer shows 1.6 ampère to be passing through the circuit, and the electrometer indicates 1,000 volts. On opening the switch d a slight increase of current is shown by the dynamometer D, while the difference of potential at E is constant. The only change in the arragement of the circuit is that the current, instead of passing through the lamp L and the coil in parallel, now passes through the coil alone, and yet, instead of 50 volts the voltmeter now indicates 148 volts. So that we apparently have 98 volts more in the circuit without noticeably changing the current; or, to look at it in another way, we have, under the constant potential at the extremities of the circuit, introduced an apparent resistance, and at the same time increased the current traversing the circuit. We have here a case similar to the former one, and as the explanation is much the same, it need not be repeated.

The question naturally arises, what influence does this new element of self induction have upon the possibilities of practical measurements of the alternating current in commercial work? As was stated in the beginning, the practical effect is almost negligible, for there are two cases in which the time element enters to such a limited extent, if at all, that the measurements may be made with perfect success in precisely the same way as if direct currents were employed.

These are, first, the measurement of current through an incandescent lamp supplied by an alternating current directly from the generator; and second, the current supplied to lamps through the medium of converters with cores far below saturation and carrying a fair proportion of their full normal load. There is a third case, however, which arises in practical work, in which the central station instruments give a somewhat false notion of the actual energy being transferred to the circuits, and this is the one in which a large number of converters are connected to the primary circuit but with the secondaries open. In this case the effect of self induction is at its maximum, and there is consequently a lag in the circuit, which, in a well constructed converter, approaches the theoretical limit of a quarter phase, at which point no energy would be consumed, while at the same time a considerable reading might be shown on the current instruments. This apparent difficulty is not a real one, since even the full amount of current shown by the ammeter only constitutes a small percentage of the total output of the plant and may practically be neglected. Even a small number of lamps in service distributed among the converters greatly reduces this error, and for this reason: Even while running with a light load the ammeter at the central station very nearly corresponds to the number of lights in service, while at full load the reading is as accurate as if the current passed directly from the generator to the lamps.

It ought to be evident, however, from what has been shown, that the method which has been sometimes adopted of turning off all the lamps from the secondary circuit, leaving the primary connected to the generator, to show the amount of energy lost in conversion, is apt to give very misleading results unless the proper correction for retardation is applied.

The best proof of economy in the use of converters is that a test of the power expended in running a dynamo at its normal electromotive force, with its circuit closed, through the primary coils of its full complement of converters is the same as when the primary circuit is entirely open, within the ordinary limits of error of measurement.

Mr. W. W. Leggett, of Detroit, then read the following paper:

THE UNDERGROUNDING OF ELECTRIC ARC LIGHT WIRES.

This topic is one of absorbing interest at the present time. Municipal and legislative authority seeks to compel the burying of all the wires without discrimination, and to cast upon the parties interested the burden of finding a practical means to accomplish the end.

The progress of invention in science and art records, infallibly, the contemporaneous public demand. This demand discloses a necessity and inventive ingenuity suggests the remedy.

Starting from this standpoint we find public wiring began with the telegraph.

In 1753, Marshall, of Paisley, evolved an electric telegraph wherein insulated wires were to be trained on poles, and so Lomond in 1787, Beton Court in the same year, Riezen in 1794, Cavallo in 1795, Salva in 1796, Sœmmering in 1809, Coxe in 1810 and Sharp in 1813 all had telegraphs employed, from one to twenty-six wires, trained on poles.

At this stage, however, the interesting experiment to which the world lent a helping hand developed signs of commercial utility and value. Man's cupidity and selfishness at once antagonizes what he cannot share, and we find the public arrayed in opposition to the use of the highways. Inventive ingenuity came to the rescue, and in 1816 Ronalds erected and used a telegraph in which some of his wires were placed on poles and *some were buried in the ground*. Tribavillet followed in 1828 with a system employing underground wires, and when Professor Morse, in 1832, brought out his system, he proposed connecting Washington with Baltimore, a distance of 44 miles. To his mind the wire should be insulated in a tube laid in the ground. He constructed his line with great care and at large expense; but only a few miles had been laid when the gradual escape from his line proved his scheme impracticable. He was about to abandon the undertaking when one of his coadjutators, Dr. Page of the Patent Office, or Professor Henry of the Smithsonian Institute said to him: "Take your wire from the ground and train it on poles." The advice was followed and success achieved.

Here then in the incipiency of public wiring is the first recorded failure coupled with its remedy. Take the wires from the ground and put them on poles.

With underground telegraph and telephone wires the electrical difficulties to overcome are much the same. Moisture must be excluded from the wires, insulation must be good and induction be reduced to the minimum, especially between adjacent lines. In both, however, leakage from the lines, due to imperfect insulation, may be compensated within limits by additional battery force. The battery acts like a pump sending water through a leaky pipe; the water may all escape before reaching the discharge end, but with a more powerful pump, while increase of pressure will cause greater escape through leakage, one may succeed in discharging a limited quantity through the end of the pipe and so accomplish the purpose sought.

For this reason underground telegraph and telephone wires may be operated with a measure of success.

In most of our cities all telegraph wires might be led to a certain point from which the wires of all systems could by one underground conduit be led to a central station or stations and thence back through the same conduit, and where the wires are numerous might warrant the expense.

With telephone companies whose subscribers are in all parts of the city, the requirements that each wire should be conveyed underground would involve an outlay for conduits wholly prohibitive.

For direct service incandescent lighting the required conductors are so large that to train them upon poles or to train an equivalent capacity in smaller wires on poles would involve outlay and annoyance exceeding that required to underground the conductors.

So again the resistance of the conductors to the flow of the current is exceedingly slight; it might be compared to the pouring of water from a pitcher through a six-inch pipe, its course of least resistance lies right forward through the pipe and there is little tendency for it to seek an exit through any other restricted channel.

In comparison with it the arc light current might be likened to a large hose with a small nozzle, through which water is being forced with a powerful pump; the tension is very great, and if so much as a pin hole exists in the hose water will squirt therefrom and quickly enlarge the orifice to a fatal rent.

From the fact, therefore, that telegraph and telephone and incandescent electric light wires may be trained underground with success, by no means does it follow that the same is true of arc light wires.

It is an undoubted fact that to successfully underground electric arc light wires involves simply and solely a question of expense. But expense may be of the very essence of the inquiry, for if the expense is out of proportion to the revenue that can be derived from the service, expense alone prohibits the outlay and determines it to be impracticable. Expenditure of money is alone required to tunnel the Dover Straits, and yet French and English capitalists have pronounced it wholly impracticable, as the returns could not warrant the investment. So it is with electric arc light wires; an efficient system so far as inventive ingenuity has yet presented any plan involves an expenditure wholly prohibitive, and for that reason alone is impracticable.

Electric arc lights wires may be employed successfully, trained in the air on poles, and an underground system is practicable which can reproduce the same conditions. Let us examine these conditions. All substances are conductors, as copper, iron, lead, rubber, glass, dry air. Some substances are such poor conductors, that, in comparison with those that are better, we call them non-conductors, and the greatest available non-conductor is dry air. We use these poor or non-conductors, such as rubber, glass, paraffine, wood and dry air as insulators, and we find dry air to be our most perfect insulator. Dry air is a better insulator than rubber; if, therefore, in dry air two rubber covered wires cross in close proximity to each other, the induction is greater between them than would be the case if both wires were bare? But air is usually laden with moisture, and water, charged as it is with the mineral salts and acids of the atmosphere, is a good conductor. We therefore coat our line wires with an insulating material, to shield them from direct contact with moist surfaces or other good conductors, and so reduce in amount the current which is always escaping by connection to the ground, and which varies in direct proportion to the conducting property of the intermediate medium.

Where insulated wires are trained on poles, we have, at the rate of 30 poles to the mile, thirty points at which a small amount of current may and always does seep off to the ground.

Now let us put an insulated cable in a conduit in the ground. The conditions are all changed in the most aggravating manner.

Instead of comparatively dry air, the air is clammy and heavily laden with moisture, instead of a mass of surrounding air as on the poles, the envelope of air is, at best, but an inch more or less in thickness. Instead of resting at 30 points in a mile on glass supports, connected to dry non-conducting wooden poles to make the passage to the ground as much obstructed as possible, the line touches the conduit at, say, two or three points in the space of every foot, or at, say, ten thousand points in a mile, and the conduit itself, a much better conductor than glass or dry wood, is all that separates it from the earth.

The bearings at which the current may leak away have been multiplied from thirty contacts to ten thousand contacts per mile, while the conductivity of the medium at each point has been greatly enhanced. A regular arched subway has been suggested and approaches most nearly to a successful plan, but only a state or city could stand the necessary outlay. A subway of this character, 4 feet wide and 8 feet high, for Chestnut street alone in Philadelphia was estimated would cost the city $1,500,000. After completion such a subway would have to be supplied with forced ventilation to keep it dry. If then the insulated wires could be supported so as to touch at but thirty points to the mile, the conditions of exterior wire training on poles would be fairly approximated.

The question is frequently asked. If telephone and telegraph wires can be undergrounded, why cannot arc wires? The reason is plain, leakage or escape can be supplied in the former by additional battery power, but an arc light generator is a queer specimen of mechanics.

It starts a mild current, and this passing back around its field magnets builds them up; the increased magnetism

induces greater impulses in the bobbins of the armature; the current thus increased continues to pass through the line and back around the field magnets until the current has reached its maximum. It is therefore apparent that any thing which seeps the current from the line, not only steals the quantity which has escaped, but prevents just so much current from passing back around the field magnets and to that extent robs the machine of its capacity to generate a current. These machines are capable of taking care of the small amount of loss at the insulators in the pole and line system, but when this is multiplied many times, as in an underground conduit, it is so robbed of its power to recuperate that the resulting lights are necessarily reduced in number, and are weak and sickly.

Operations looking to the undergrounding of arc light wires have been prosecuted on a large scale at New York, Brooklyn, Chicago, Philadelphia and Washington.

Notwithstanding all reports to the contrary, I find that at New York, although the Subway Commission has expended vast sums of money and has succeeded in burying certain telephone and telegraph wires, no arc light line has, up to this time, been buried in New York city, and this is fully corroborated by the report of the Board of Electrical Control of Jan. 6th, 1888.

At Brooklyn, N. Y., the Board of Commissioners of Electrical Surveys instituted thorough investigation of this subject in 1886, and in its report of Dec. 30th, 1886, says:

"With regard to electric light conductors this board has found no device which would, with certainty, in its opinion, enable the wires carrying arc light currents to be safely and successfully operated in the same conduit with telephone and telegraph conductors without disturbance or injury to the latter.

"But the board desires to say, emphatically, that those fluent critics who talk of putting electric light conductors underground, making no distinction between arc lights and incandescent lights, or between the arc lights of different systems, are ignorant of the alphabet of the subject."

The president of the board visited all the principal cities in Great Britain and Europe. He found no arc light wires underground, and although a few years since such wires were trained in the Paris sewers, they have been removed, and no arc light wires are now allowed therein.

The Brooklyn Commission made another report Dec. 15, 1887, and on this topic says: "As was fully explained in the last report, the subject of underground conduits for arc currents is the one which presents the most numerous and novel difficulties.

"Since it has been impossible for Brooklyn to take the lead in the experimental solution of these, the only remaining course was to watch carefully the progress of experiments in other cities. This has been done, both by correspondence and by personal visits of members of the board. The principal cities in which experiments of this kind have been in progress are New York, Chicago, Philadelphia, Baltimore and Washington. In one or another of these, several systems which were regarded with favor a year ago, have since developed defects or even come to entire failure.

"It cannot be said that any system has yet been completely proven to be permanently satisfactory. There are one or two, however, which promise well, and this board awaits with attentive interest their further trial, regretting only its inability, through the cause already specified, to co-operate in the experimental investigation of the different and delicate questions involved."

There are no arc-light wires underground up to this time in Brooklyn.

At Washington in 1884, cables were laid in F street from 9th to 15th.

In a few months, it was necessary to dig up a few of the same. Later, there was much more trouble and it was all taken up and relaid.

About one year after the first laying it was wholly abandoned because they could not make it work.

In 1885, they laid cables on Pennsylvania avenue from 9th to 1st streets, and imported an expert from Antwerp to lay them. Twelve cables were laid in solid cement and no expense spared to insure success.

They proved an utter failure. The avenue was dug up many times. The wires were in September, 1887, mostly out of service and the remainder were in such bad shape that they would require constant repairing or have to be abandoned.

An officer of the Washington company writes me under date of September 12, 1887: "We have many committees coming here to see what we have accomplished, as they have heard that we have met with great success and so forth. We will say to you: that our experience, after the outlay of many thousand dollars, is this: have nothing to do with underground cables for arc lighting if you can possibly avoid it. Many will tell you that it is perfectly practicable; look out for such parties; they are probably interested directly or indirectly in cables. There is a big obby in that branch of business. There is no city or town in the world where a cable has been made to work two years that has been subjected to 2,000 volts of pressure."

This Washington company is using lead covered cables with success for incandescent work; but as to the undergrounding of arc light wires, confirmed as late as Feb. 7, 1888, they report that out of 14 miles of arc light cable, in fourteen different circuits all have proved total failures, and have been abandoned except a very small amount.

At Philadelphia elaborate experiments have been prosecuted. All kinds of cables have been employed and a great variety of conduits—great trouble has been experienced. The systems largely employed were such having ducts through which the cables were drawn—in most cases the insulating compound rapidly deteriorated and became useless; in others it would be rotted and become water soaked. Where lead covered cables were used in conduits where creosote was employed, the effect was to rapidly oxidize the lead covering and disintegrate the same. It was found that gas could not be kept from the ducts; although apparently gas tight, many explosions followed. Recourse was then had to ventilation by lamp posts, but the trouble was not corrected. After several explosions in one system, in which persons and property were injured, a power fan was adjusted to force air through the conduit, deeming it better to do so, than to draw the air through, which might simultaneously draw in gas. When shortly afterwards the lighting company was congratulating itself that it had overcome the difficulty, a tremendous explosion ensued, extending for a long distance, ripped up the street and broke a large plate glass window. That entire system of lights had to be abandoned. It was some six months ago determined by the manager that as a result of experience no conduit would suffice for arc light wires in which there were open ducts, and that success lay in the employment of lead covered cables buried solid. This plan suggested by the city electricians was tried and success seemed assured, but they now report the experiment unsuccessful. The section covered is not great, but three bad grounds have recently developed; two were repaired, but the third necessitated the temporary cutting out of a part of the line and the training of wires on poles until the earth may thaw and enable access to be had to the wires.

The various companies of Philadelphia are at a loss what to try next. At this point I would note that these demands for a system for arc light wires have greatly stimulated inventive ingenuity, but as yet without success.

Out of the 72 patents that have been issued in this line, 53 of them have emanated from Philadelphia, New York, Boston, Brooklyn, Wilmington, Camden and Washington, all being in the immediate vicinity of the places where the operations were being conducted. The others were mostly from the general vicinity of Chicago.

Now as to Chicago, much has been said of its system. A visit to Chicago satisfied me that its electric arc light industry was being strangled.

A few blocks in the immediate heart of the city were using electric light very lavishly, but the area lighted is scarcely a half mile square. This small area is served from no less than nine separate plants, formerly belonging to as many companies, but now consolidated into one.

A letter under date of Sept. 20, from an officer of the consolidated company, explains the situation there. He says: "We have had an enormous amount of trouble with our underground arc light circuits, averaging, I would say, for the last three months, one burn out every day. The expense of reconstruction and the losses in rebates have been enormous, and the annoyance to our customers more damaging still. Commencing in April last we bought out some nine arc light plants in Chicago, and have proceeded to concentrate them into four main stations burning about 1,100 lights; their owners had all been using underground conductors composed for the most part of okonite, kerite, callender and underwriter's wires. Every one of these insulators has failed constantly, the only thing that has held up at all is lead covered cable, and we have been driven to the great expense of taking out every foot of the old constructions and substituting new lead covered cables throughout. This work is not yet done. Our people are confident that a large business awaits us here, but its development will depend entirely upon service. These lead circuits may fail much sooner than is anticipated, and it is almost certain that we shall be compelled to reduce the number of lights upon a circuit, a very difficult matter in a city like Chicago. Our conduit space is already filled along the main routes and additional conduits will be necessary. The constant tearing up of the pavements for all kinds of purposes makes our street departments very unwilling to grant permits for laying additional conduits and several times they have been refused altogether. I would say here that arc-light business in Chicago has developed entirely since the passage of the underground ordinance of 1881. The result has been the multiplication of small isolated plants and the formation of the nine small central station plants bought out by this company. None of these plants made any money. It was impossible for them to do so, operating underground and upon so small a scale. No streets have ever been lighted by electricity here, in fact the whole industry is in a very backward condition, and is likely to remain so, except in the most densely crowded portion of the city, unless some arrangement can be made with the city authorities for overhead wires. The city is trying an experiment of its own in lighting Chicago River, which will, I am confident, demonstrate the truth of the foregoing statement: and in the course of a year I hope that our city fathers will permit overhead lines, in many places where public convenience demands electric lights, while underground construction would forbid it."

At Milwaukee, Wis., three systems have been tried and abandoned, *i. e.*, a wooden trough plain and tarred iron pipe, and grooved wood. A fourth, consisting of tile conduits, with a heavily insulated, but not lead covered, cable has recently been introduced and is now being tested. The company doubts whether it will stand the trying spring season.

At Detroit, the Thomson-Houston Co. employed a cable of the most expensive and approved character in the Dorsett conduit, and the mechanical work was of the best quality.

While the cable was new the results were fair, though loss by seepage rendered it impossible to produce normal lights.

It was found impossible to operate telephone wires in the same or adjacent pipes. The company soon abandoned the system, and when its cable was removed it was found the insulation had so rotted or softened that considerable lengths of the wire in many places were stripped bare.

With the alternating system some wires have been undergrounded in Springfield, Mass., and in Denver, Colorado, and a small amount in Pittsburgh, but the voltage is only half that of the arc light systems, and even with this low voltage the lead-covered cables have not been in use long enough to determine the question of their success.

The difficulty from explosions of gas has been met with many times at Chicago, New York and elsewhere, as well as at Philadelphia, and seems insurmountable where gas is employed. At New York men have been suffocated in the main holes, and in the Western Union Building the escape of gas from their conduits has been almost unbearable. At Detroit an explosion took place in October last in the middle of the night, in a fire alarm conduit with closed man holes, and in which no wire had ever yet been placed. It doubtless occurred through the admixture of illuminating gas and sewer gas or other exhalations, in proportions to explode spontaneously. The man hole cover was thrown high into the air, the street torn up, and the paving blocks scattered over a distance of eighty feet or more.

The problem of undergrounding arc light wires is by no means solved, but appears to-day to be further than ever from solution owing to the utter failure of systems which apparently had all the elements to insure success. In this emergency municipal bodies must suit their action to the facts. To legislate arc light wires beneath the ground when no practical system is presented for accomplishing that end, is actually and literally to bury the system.

When a city is so sanguine of the soundness of its judgment the remedy would seem to be for the city to provide conduits and the necessary cables, guarantee their success, and then compel lighting companies to rent their lines at a proper figure, or failing so to do to quit the field.

Summary action on any other basis is incompatible with that justice and equity which it is the inherent right of every person to demand and receive. Any other course is to discourage enterprise and to ruthlessly impair or destroy capital invested in good faith.

The difficulty usually met with is a peculiar and unreasonable one. Municipal and legislative bodies view with suspicion the lighting companies, their officers, stockholders and everybody connected with them. It seems to be assumed that because the companies make a certain showing of facts the facts must necessarily be exactly the contrary, and they legislate accordingly. Thus at Detroit, in opposition to letters produced by the lighting company alleging repeated trials and failures at Washington, Philadelphia and Chicago, the then mayor, unquestionably in good faith, reported to the council as the result of his personal investigation upon the spot, that no electric light wires had ever been buried in the city of Washington, a most glaring error; yet this was followed by a report of the committee and unanimously adopted by the council, that underground systems of electric arc light wires were entirely practicable and were in successful use at Washington, New York, Philadelphia and elsewhere. At Cleveland recently the strongest argument in the underground struggle advanced by the city was that the wires of the Thompson-Houston Company, of Detroit, were operating underground in the Dorsett systems, whereas not a foot of arc light wire is underground in Detroit. To combat this unreasonable and unreasoning prejudice, the question whether any system yet discovered is practical and sufficient for the purpose should be thoroughly and exhaustively examined, and an elaborate report made and published with full data upon which the conclusions are reached. This should be done by a board of competent and eminent men of national repute entirely disconnected from the electrical business, such as could be gathered from the scientific chairs of our largest colleges and polytechnic institutes, and it would rest with the interested companies of this association to contribute from their own funds or to influence the necessary contribution by the councils of their respective cities to pay the necessary expenses of such an inquiry.

Mr. J. M. Smith then read a paper on

UNDERGROUND CONDUCTORS FOR ELECTRIC CURRENTS.

The question of underground conductors of electric currents is one which every person interested in electricity should study fairly and with a predetermination of solving.

It is not purely an electrical question, in fact the electrical part of it is far overbalanced by the mechanical.

There is no difficulty in finding an excellent insulating material, but the difficulty lies in the holding of this insulator on the conductor.

Many substances are good insulators in dry places; some are good under water, some in damp places, and a few will stand acid and alkaline fumes and the ravages of sewer and illuminating gas, but how many will insulate under all these conditions and in addition be substantial enough to withstand the mechanical injuries to which they are exposed when buried under the streets of our large cities?

A few years ago wire wound around with a little cotton soaked in paraffin was thought sufficiently insulated until the insurance companies had a few losses, due of course to electricity, and then we had underwriter's wire.

The name of this wire has sold hundreds of tons of it, but that does not prevent its grounding a whole system when it comes in contact with the least moisture.

It, however, marks one state in the evolution of the perfect insulation.

There seems to be comparatively little difficulty in making a cable that will carry high potential currents when constantly submerged.

The conditions are substantially the same at all times. There are no alternate changes of moisture and dryness, no great changes of temperature, and very little of the destructive action of gases.

The conditions of the underground conductor are very different.

Here the conductor is dry, then wet; it is frozen, and again thawed; it is attacked by sewer gas, and the corroding action of the water leaching through the accumulated filth of the street: it is subject to the destructive action of the leaking gas and steam pipes and finally, but not the less surely, to the ruthless "ditch digger."

These are certainly formidable obstacles, but a number of them have already been overcome, and the others must be.

Public opinion says the wires of all kinds must go underground, and electricians, engineers, and capitalists must find the means of doing it.

The question resolves itself into three parts.

1st. The electrical insulation of the conductor.

2d. The protection of the insulator from the effects of moisture and corrosion.

3d. The protection of both from mechanical injury.

The question of electrical insulation seems to me to be solved by at least six of the standard compounds now in daily use.

The second part of the question is the most serious.

If any of the standard insulations can be inclosed so as to be protected from direct contact with moisture their chances of life are certainly improved; but if they can be hermetically sealed, they should be practically indestructible provided the casing is indestructible.

We single out as among the best materials from which to form such a casing—iron and lead.

Cast iron, underground, will last a great number of years, as shown by gas and water pipes, but it cannot be obtained in lengths much over 13 feet, and the numerous joints multiply the chances of leakage. The conductors must of necessity be drawn into the pipe after it is in place.

The conductor must be considerably smaller than the pipe, and therefore moisture will creep in between the two.

Wrought-iron pipe, if well coated with asphalt or some similar substance, will last a long time.

It may be had in longer lengths than the cast pipe, and the joints are more easily and surely made.

If screw threaded joints are used the conductors must be drawn in, with the same objections as with the cast pipes. If the lengths of pipe are prepared with the conductors in them before laying, joints must be made in the conductor as well as in the casing, at short intervals.

Joints are the bane of electrical construction.

From the dynamo to the lamp and return the current is forced to pass joints which frequently offer more resistance than 1,000 feet of wire.

At these joints the insulation, instead of being better than at other points of the conductor, is generally worse, and oftentimes none at all is found.

It is not strange that the current should seek an easier path home, and take to ground, rather than be forced through the accumulated resistance of all these joints.

I will venture to say that, of all the failures of underground conductors, 90 per cent. are directly traceable to the joints, and for that reason it is desirable to have as few as possible.

The conductor may be obtained in, practically, any length, and the insulation may be put on continuously; but in order to have a continuous casing it must be formed of some sort of ductile metal which can be closed about the insulated conductor in the course of its manufacture.

Lead seems to be the only commercial metal that will find these conditions, and there are objections even to it.

Lead is soft and easily punctured, and offers little resistance to crushing or bending, and is attacked by rats.

On the other hand, the corrosive action of the earth has little effect upon it, while its pliable nature permits of its use in many places where iron pipes could not be used.

Being soft and ductile it can be brought into such close contact with the insulation as to prevent or at least retard the creeping of moisture between the insulation and casing.

It seems to me, therefore, that lead casing offers more advantages and less objection than any other form of protection to insulation as yet open to our use.

The third part of the question, viz: the mechanical protection of the casing and hence the conductor is not so difficult a matter.

If an iron casing is used little or no protection is needed. The pipe is strong enough in itself to withstand any ordinary abuse.

If lead is used, however, it should be kept from contact with sharp stones, bits of glass or metal and have some thing about it to warn the ditch digger before he strikes it with a pick.

An ordinary square wooden box is oftentimes sufficient. If it does rot away it leaves a bed of soft mold.

The box may be made of white oak, well creosoted, in which case it will last until the next generation finds something better.

If the underground conductor is to come into practical every day use it must be so constructed that it may be tapped at any point as readily and with as much certainty as a water main is now tapped.

How many miles of lead water pipes are now buried in our streets?

They are not protected by boxes or conduits of any kind, yet it is comparatively rare that we hear of their failure.

If such pipes filled with water can be laid in the earth without protection, why cannot a lead pipe filled solid full with copper and insulation be buried with even more success?

Good workmen can certainly be found who can cut a conductor, splice in a branch and solder it, replace the insulation, and finally wipe a joint on the lead casing with as much ease and certainty as a plumber can make a joint in a lead water pipe and have it stand 100 pounds pressure.

In a general system of distribution there are two classes of conductors, one which we may call through mains or feeders and another service mains.

A number of through mains may be bunched together in a cable under one casing, where they run in the same direction for considerable distance. These may be drawn into conduits, as they are not to be used between the main distributing points.

Service mains must, however, be so constructed that they may be tapped at any point, and that very readily.

Large sums of money have been spent in New York and elsewhere on conduits for electric conductors.

Are conduits necessary or desirable in electric lighting? Service wires are of no use whatever if placed within them, unless manholes are provided at every 100 feet. Though mains are certainly well protected when drawn into conduits, but at a great expense, no engineer would, I think, at this day, risk putting a conductor in any conduit which he would not be willing to trust under water or laid directly in the earth.

Why not take one-half of the money which these conduits cost and use it in buying thicker lead casing and bury the conductor in the ground or in a common wooden box?

The underground conductor of the future, I believe, will be formed with a core of copper cable, thoroughly insulated by any of the standard and well-tried compounds, protected by a close fitting lead casing, thick enough to resist mechanical injury, and buried in the earth in such a manner that it may be tapped at any point. But where is the money coming from to pay for these conductors?

Whenever electric light plants are installed in a thoroughly mechanical and substantial manner, with due regard to the most economical production of power, so that the electric light is perfectly reliable and obtains public confidence, then the money will be forthcoming.

When capital enough is invested in electric lighting to enable it to cope with the vast sums which have been accumulating these many years in the gas industry, then we shall see our dynamos driven by the waste heat and refuse products of the gas works, and our houses will be heated by gas and lighted by electricity.

Mr. MOSES: I have the pleasure of announcing to the convention that we have in our midst this morning one of the most distinguished electricians of England, Prof. George Forbes, to whom the courtesies of our association have already been extended. As he is full of ideas, even to overflowing, he will perhaps allow us to puncture him somewhere so as to enlighten us. I hope that he will give us his views in the discussion of these various papers, or in making any suggestions which he may think apposite to the subject. I know that it will give us all very great pleasure to listen to him.

Prof. FORBES: A great deal of the matter of the papers which have been read has referred to the question of insulation, and as to the laying of overhead and underground conductors. Our experience in England of course as to underground conductors is absolutely nothing almost for the simple reason that our people will not allow us to put our conductors under ground. The public in England have a strong feeling that there ought not to be any overhead conductors; they would not allow wires on poles as you have them here—which is a very cheap and convenient method—and our telephone wires have hitherto been carried from roof top to roof top, standards being erected on the roofs; and there is a general feeling among the public that electric light wires ought not to be overhead and ought to be underground. An electric light company also feel that they would prefer to put their wires underground. The opinion seems to be different over there to what it is here. The idea in England is not so much to make a cheap outlay at the start as it is to make an efficient system—a system which it will be able to work afterwards. It is the general opinion of a great number of companies that the best arrangement could be got by underground work. However, Mr. Chamberlain, in 1883, thought it wise to practically to prohibit electric light companies from putting their wires underground. The consequence was that for several years after that it was absolutely impossible to start a central lighting station. At the present moment the demand for light from central stations in England has become so great that the companies who are capable of doing the work are determined that they will satisfy the public demand, and the consequence is now that at the present moment central stations are being started in London and in other towns, but always on overhead systems. That is what the Government has driven the electric light people to in England. I may mention that the insulation which is used in electric lighting overhead work in England for the alternating current, where 2,000 volts are used, is very superior to what you are using over there. The best possible insulation, of India rubber and tape of several servings, is being used in the central station lighting, which is done on a large scale there, viz., from the Grosvenor Gallery in London. I have always thought that that was very wise, but I must say that from inquiries here among those who have been using alternating currents of high potential I find that a less expensive wire is certainly doing admirably, and I think it is just possible that we have, perhaps, overdone the matter in England in the way I speak of.

Prof. Forbes then referred to Mr. Shallenberger's paper and mentioned a formula by means of which the current restored to the circuit could be obtained. He then referred to the subject of alternating current meters and asked in regard to what had been done in this country in that field.

Dr. MOSES: One of the first ideas evolved as to the distribution of electric currents over large areas for ordinary use as a substitute for gas for illuminating purposes was a meter, and it was resolved to adopt a continuous current, not because a continuous current machine as then known was better than an alternating machine, but simply because continuous currents permitted of the registration of the amount of electricity consumed in any work by the various methods known at that time. When that was finally adopted by Mr. Edison, who first worked in that direction, he took the electrolytic method. The fame was also spread abroad among the people at one time to the effect that the Pixii and other machines which generated alternating currents were highly dangerous. For that reason alternating currents were abandoned, and for no other reason that I know of. I have lately seen a meter in the Westinghouse factory which I would take occasion to particularize here as being one most admirably adopted to the registry of alternating currents, and with this excellent addition, that it will speak the truth; and with this corollary to it, that we can verify it ourselves; and we do not need inspectors to go around; we do not need to use weights and measures made by ourselves. I have to speak guardedly of this, because I was told at the time that the meter was shown to me, that while it was shown, still for certain reasons connected with the taking of European patents and such things, it was not desirable that the particulars concerning it should be promulgated; but I vouch for its success and accuracy.

Mr. LOCKWOOD: I would like to ask Prof. Forbes a few questions with regard to underground wires in England. In 1881 and 1882 I had occasion to be in London and investigate somewhat while there the underground wires of the Brush Company operating the Brush system, and the Electric Light & Power Generator Company of London operating the Weston system. I understood while there that within one year's time the Brush Company were forced to renew three times their cables which they had laid down Cheapside in the lower part of London, and that each time they put in the kind of insulation that Prof. Forbes speaks of as being preferable in England—the India rubber insulation: their cable being laid at that time by the India Rubber & Gutta Percha Telegraph Company. I do not remember whether the Weston Company had replaced theirs so many times, but I think they were replaced twice.

Prof FORBES: I can support what you say has been said about the failure of the Brush Company's cables, but I do not think that the statement is correct that they were the work of the India Rubber and Gutta Percha Company. I do not think that that was the case. The cables certainly were continually giving out with faults in different parts, and enormous quantities of the cables had to be laid; and, even when they were working at their best, the insulation on the line varied enormously with the weather, so much so that on some days it was really almost impossible to work them. Eventually, as was stated just now, the whole of the cables had to be taken up. The best underground cables that I know of are at the works of the India Rubber and Gutta Percha Telegraph Company, there they have had their cables lying for about six years, and lighting the whole of the arc lights in their large works. They are laid in a conduit, which however is not water-tight, and the cables in some parts are dry, and in some parts wet, and in other parts are alternately wet and dry; and they really undergo serious changes by the action of the water, as could be expected: and yet they have been maintained admirably during the whole of that time.

Mr. LEONARD moved that the paper of Mr. Leggett be printed in pamphlet form for distribution. But upon discussion it was thought best to await the publication of the proceedings, in which the papers would appear.

The association then took a recess until 2:35 P. M.

SESSION OF THURSDAY AFTERNOON.

The convention was called to order by President Morrison at 2:50 P. M.

The secretary read a communication from Mr. Benjamin Rhodes, manager of the Brush Electric Light Company, of Niagara Falls, inviting the association to meet at Niagara Falls next summer. Received and filed.

The Committee on Amendments to the Constitution submitted the following report:

The Committee on Amendment of the Constitution respectfully recommends that article IV. of the Constitution be amended to read as follows:

Article IV.: The President and Vice-Presidents shall be elected by ballot to serve from the close of the annual meeting at which they are elected, until the close of the next annual meeting, and the same person shall not be eligible for the office of President or Vice-President for two successive terms.

The treasurer and secretary, who may be one and the same person, shall be nominated by the president subject to the approval of the executive committee, which shall have power to fix a proper compensation for his services, subject, however, to the approval of the association. The executive committee shall be chosen by ballot at each meeting, either annual, semi-annual or special, to hold office from the close of the meeting at which they are elected until the end of the meeting at which their successors are chosen.

On motion of Mr. Mason the report of the committee was made the special order upon the first day of the reassembling of the convention.

Mr. Mason then moved that a committee of five be appointed by the chair on revision of the constitution.

The motion was carried, and the chair appointed as the committee Mr. Mason, Mr. Leggett, of Detroit; Mr. Phelps, of New York; Mr. Stanley, of Bridgeport, Conn.; and Mr. Porter, of Pittsburgh.

Mr. DECAMP moved that pending the adoption of the amendment to the constitution bearing on the subject, the salary of the secretary and treasurer be fixed at $900 per annum. The motion was carried.

The committee to nominate officers presented their report through Mr. Garratt, naming, for President, S. A. Duncan, Pittsburgh; First Vice-President, E. R. Weeks, Kansas City; Second Vice-President, A. J. DeCamp, Philadelphia. For Executive Committee, Dr. Otto A. Moses, Chairman; J. Frank Morrison, Baltimore; E. T. Lynch, Jr., New York; Frank Ridlon, Boston; W. L. Strong, New York; T. C. Smith, Pittsburgh; E. F. Peck, Brooklyn, N. Y. As the Constitution only calls for six members the name of Mr. W. L Strong was withdrawn from the committee.

The committee to whom was also referred the place for holding the next meeting also recommended in their report that the next semi-annual convention be held in New York.

The secretary was instructed to cast the unanimous ballot for the nominees as above and they were declared elected.

The PRESIDENT: Gentlemen, I have the pleasure and honor of introducing to you your duly elected president. He will find the office of president of this association a pleasant one if the same courtesies shall be extended to him as have been extended to me. (Applause.)

Mr. DUNCAN: I should be devoid of feeling did I not appreciate the honor you have conferred upon me, especially when I recognize the fact that I am to succeed a man who, by his influence, as well as by the power of the gavel, which has been the only symbol of authority in this association, has welded together and made the association what it is to-day. Three years ago, in Chicago, a few representatives of electric lighting interests met and elected my predecessor, Mr. Morrison, as their president. From that time on he has continued to direct and control, with the advice and assistance of the Executive Committee, this association. It has grown in membership and influence until to-day it represents in its membership millions of capital and the intelligence and brains of the electric light interests of this country.

I shall endeavor, gentlemen, to bring to the discharge of the duties of president of this association all the ability that I have, and I shall discharge those duties with fidelity to the best interests of this association. Promise is good, but performance is better, and you will better be able to decide upon the wisdom of your choice in the future than you are to-day, and I can only thank you for the compliment you have paid me and ask your indulgence for my failures and for probable inconsistencies in the rulings of the chair until such time as you have proper by-laws and parliamentary rules for your government. I have no doubt, gentlemen, that you will place the same confidence and trust in the integrity of the chair in the future which you have in the past, and with your co-operation and assistance and with the aid of the retiring president I hope and trust that this association will do better, or as well at least, in the future as it has done in the past. Thanking you for your consideration I conclude by assuring you that I will endeavor to discharge the duties of the office to the best of my ability. (Applause.)

Mr. FOOTE, of Cincinnati, proposed that city as the next meeting place of the convention, but a motion to that effect was lost.

The recommendation of the committee that New York be the place of the next meeting was unanimously adopted.

The discussion on underground wires was then resumed.

Mr. B. E. SUNNY: The statement was made this morning, in the very excellent paper read by Mr. Leggett, that while it was entirely practicable to work telephone and telegraph wires underground, it was not practicable to do so with electric light wires. I remember distinctly that, six years ago, when the question of putting wires underground in Chicago first came up, the telephone interest gathered its experts together, and in meeting assembled they each and every one of them avowed, with all sincerity and earnestness, that while it was possible to work telegraph and electric light wires underground, it would be utterly impossible to operate telephone wires in that manner. The amount of crow that we have been compelled to eat in that time can be estimated when it is understood that there are 2,000 miles of underground wire working in Chicago to-day. As a matter of fact, the whole electrical interest opposed the measure and left no stone unturned to defeat it. The more they fought, the greater became the general clamor for the removal of the wires. The same thing occurred to which Mr. Leggett referred as having occurred in Detroit; the statements put forth in good faith and all truthfulness by the electrical fraternity were discredited by everybody on the other side. The authorities exercised their power in its severest form by ordering the removal of every pole and wire from the public streets within a specified time. The prohibition included the entire city of 48 to 60 square miles, acres upon acres of which are vacant;

miles upon miles of the streets of which are uninjured and sparsely settled, and alleys in passing through which one instinctively holds his nose and breathes as little as possible.

The point that I think can be made is that it is not the best policy to fight a measure in which the public seems to be so greatly interested, but to find a way to give them 10 or 15 per cent. of what they ask for, if in reason it can be done. I think now that had this course been pursued in Chicago we would now be able to string wires in the air outside of a limit of two or three square miles. Chicago has a thousand arc lights on underground circuits in the centre of the city, the greater number of which are in the districts served by the main station located on the Chicago River at Market and Washington streets. Most of the lighting is east of this point, so that 25 circuits, or 50 wires, run practically together for 2,000 or 3,000 feet.

When this station was established several months ago a conduit of 12 creosoted wooden tubes was put down to connect with the Dorsett conduit built four years ago. The Dorsett conduit is made up of pipes having seven ducts or holes 2¼ in. in diam. Six lead cables of $\frac{5}{32}$ inch insulation, No. 6 gauge, were drawn into each duct. Lead cables were used in preference to anything else, because of the difficulties experienced in maintaining the insulation where other makes—a good many of them considered first class—had partly or wholly failed. Many of the conductors having no lead covering have done and are doing good service in various parts of the city, but in the business portion, where the earth is saturated with water gas and sewer gas, which circulates more or less freely through the conduit, nothing but lead seems capable of withstanding their influence. The six cables in each duct were made into three circuits—three positive and negative—and this arrangement is probably responsible for some of the trouble experienced. It was found that, although the insulation measurement of the lead cables in the conduit was very high—considerably above a megohm—and the insulation beyond the point where the lead cables ended and where some other wire was used was with, say, 500,000 ohms, a short circuit would form, generally within 1,000 feet of the station, between the two sides of the circuit. The heat generated at the point of the short-circuiting would melt the lead in the adjacent cables, so that in one instance all six wires were rendered useless. Where this occurred in the Dorsett conduit the destruction did not go beyond the six wires, while in the creosoted wooden tubes on another occasion not only were the six wires destroyed, but the inflammable material of which the conduit is constructed resulted in the burning out of the entire conduit and the 60 cables in it. The cold weather of three months had frozen the earth to a depth of four feet, but when the street was opened it was found that the fire had taken the frost out of the earth below a foot from the surface, and that there was left for a distance of 12 feet a few charred sticks, the bare copper wires and in the bottom some lumps of lead. Iron pipes were put in and lead cables of five thirty-seconds insulation used—four of which were put in each duct or iron pipe. This heavier insulation, coupled with the redistribution of the circuits, so that positive wires are grouped and kept away from negative wires, will probably result in eliminating this source of trouble.

Looking for the cause of these burn-outs, it was found that they occurred on circuits carrying as few as 20 lights, or 900 volts and 10 ampères, and on circuits carrying 48 lights, or 2,160 volts and 10 ampères. They generally occurred near the station, although there was an insulation of $\frac{6}{32}$ inches between the two sides of the circuit measuring considerably above a megohm, and there were weaker places beyond, indicating that the nearer the station the greater is the liability of short circuiting.

It seems incredible that the $\frac{5}{32}$ inch insulation around each conductor would not carry this voltage, while the same make of cable of $\frac{5}{32}$ carries a greater voltage in another part of the city. We could not in any instance of a burn-out find that an abnormal resistance had entered the circuit beyond the place where the burn-out occurred. On the contrary, as soon as the damage was repaired it was found that the circuit was in good order. Without being entirely at rest as to the exact cause of burn-outs we have adopted what might be called a whip handle method of insulation—very heavy at the station and tapering towards the outer end of the circuit. This, it is expected, will enable the conductors to hold the current within them, under all conditions.

So much work has had to be done in the main route on account of the burn-outs that we have had to make almost constant use of the man-holes in the conduit. We find now that these man-holes are all too small, and must be increased from 3 feet 6 inches diameter to 6 feet if possible. The suggestion is made that the latter size ought to be secured wherever possible, because of the impossibility of properly putting away the labyrinth of wires and cables that must be provided for at these points.

Mr. T. C. SMITH: I wish to state that our company here in Pittsburgh is probably as much interested as any company in the country in aerial wires. We have an enormous amount of pole line already set up in this city, and we are doing immense business from that pole line, and I do not know that we should feel inclined to take the whole of that wire down and go underground within a year, or within two years. But it is very evident that the public demand is urgent that the wires be put underground wherever feasible, and our company, without being asked by the city, and without any ordinances being passed to compel us, has voluntarily undertaken to try the experiment thoroughly. We have seen a great many people try to put their wires underground, and in most of the cases which have come under my personal observation, the work has been done in such a manner that it is not a wonder that the cables burned out or that they ever got current through them. As Mr. Smith, of Detroit, has remarked, it is much more an economical question than an electrical one. With regard to one of the conduits of which Mr. Leggett spoke in his paper, viz., the conduit in Chestnut street, Philadelphia, I happened at the very time that the conduit was being put down there to be connected with another company in Philadelphia which was also putting in underground conduits. The underground conduits which our company laid were nothing but a lot of tin tubes put in a wooden box filled with pitch, and we hauled into it first-class lead covered insulated cables. We ran them for six or seven months without the slightest hitch and without a single burn-out. At the time that the cast-iron conduit was laid in Chestnut street it was laid without any attempt whatever to keep it water-tight or air-tight. It was nothing but an iron trough in two halves, and they made the absurd attempt to keep it air tight by putting putty along the edges. I saw a good many cables being put in, and in some of the cases where lead cables were used the ends of the cable were simply stripped for two inches of the lead, the ends spliced, and three or four turns of tape put around it. Yet that has been cited as a dismal failure of underground work. Now, I am not by any means arguing that all wires must go underground for the simple reason that companies that have spent an amount of money and have large vested interests in pole lines and wires and business cannot be compelled by any equity to remove the whole of that property and put it underground. In a great many cases it would be equivalent to sending the company out of business. But I do think that companies should endeavor in the central parts of cities where the streets are crowded and the buildings are high and there is no doubt that the overhead wires are a nuisance—that they should make an honest endeavor to put them underground. With first-class work I see no reason why underground wires should not be successful. We have heard a great deal about the punching of holes through these cables. Any one who has had anything to do with arc light machiney knows that if you take a 40-light Thomson-Houston machine or a 60-light Brush machine and open the circuit suddenly you will discharge the field magnets into the line, and if there is any weak spot in the insulation it will go through it at that instant. We have demonstrated it over and over again. I think if the gentlemen who are trying underground wires will simply shut their dynamos down regularly by either short circuiting the armature or shunting the field circuit, that they will do away with a great deal of this punching of holes in the cables. In laying down three or four miles of lead covered cables we cannot expect to find them perfect in every part. There will be pinholes occasionally and the best inspection will not always discover them, but we have no right to assume because such things as that occur that the plan is impossible. There is not a man here present who has been in the electric business for a year who has not had a hundred cases of open circuits and short circuits on his overhead lines. The question is not whether underground wires are feasible or not, but whether we cannot get them established with about the same trouble we took to get our overhead lines in position. I am interested in a company in Philadelphia which is running the underground system entirely. We started with a 200-volt direct current system, and used the best lead covered cable, put down by the most experienced men. We operated them six months without a trace of leakage, and then we changed over to the alternating system. We put a thousand volts into those cables, and they are running to-day and have been for nine months without a single ground having occurred on them. We have fifteen miles of cable buried all told. We have had the question before us as to whether it would not be possible to run the alternating current in the same box with telephone and telegraph cables. At the request of Chief Walker, the city electrician, we ran in the Long Distance Telegraph Company's conduit 1,500 feet of 3-conductor cable. On the two outer wires we put our alternating current, and we placed a 20-light converter in the chief's office. Into the third wire we connected his telephone, and there is not a trace of interference on it. The telephone company, of course, had given Chief Walker permission to put that cable in their box, but they were a little nervous about the result, being afraid it would knock out their whole system between Philadelphia and New York. After we had been running about a week they came to us and wanted to know when we were going to start up. We told them that we had been running about a week, at which they were very greatly surprised, and they have made no objection to the occupation of the box by us. Of course I have had no real experience with arc lights underground, that is, high tension currents, beyond the fact that when I put down my lead cables in Pittsburgh I use a 65-light Brush machine to test them with.

We have proved beyond any question that the alternating current can be put underground and can be put in lead covered cables without any danger of loss of current. If the direct wires cannot go underground, the alternating can. And it may be that we shall be called upon to put in new apparatus which we do not want, simply because it cannot go underground. I think that in a case of this kind it is not the technical press we have to consider; they can realize the difficulty and danger and troubles of going underground. But it is the public press we have to consider. While they certainly do not always express public opinion they have a good deal to do with molding it, and a persistent attack by the press on a lighting company will compel it to do what they desire. I think the sooner this question of underground wire is placed fairly, the better it will be for all of us.

Mr. WILBUR: Last spring we laid over two miles of underground cable in Philadelphia in the grounds of Girard College. We are running 47 lights on two 25-light machines. We have never experienced a particle of trouble with the cable from the time it was laid up to date. Where the cables come out at the top and are connected with overhead wires there have been one or two grounds and leaks and lightning troubles, but no serious defect of the cable.

Mr. DUNCAN offered a resolution that a committee of three on transportation be appointed, one in Pittsburgh, one in New York City and one in Chicago, or adjacent thereto, dividing the country up into districts from which railroad centres can be easily reached.

The resolution was adopted, and the following committee appointed:

T. Carpenter Smith, of Pittsburgh; Geo. F. Porter, of New York; and Mr. Geo. S. Bowen, of Elgin, Illinois.

On motion of Mr. Garratt, the courtesies proffered by the New York Electric Club were accepted.

Dr. MOSES: I have drafted resolutions which I know will meet with unanimous approval on the part of the convention. I will make no preamble, because you all have in your minds whatever I would say on the subject. I will simply read the resolution:

"*Whereas*, It has pleased Mr. J. Frank Morrison to insist upon not being re-elected to the position of President of the National Electric Light Association, which he has continuously held since its organization; and,

Whereas, We have tacitly agreed at our successive re-elections of him to allow him to retire (as he has invariably requested at each meeting) whenever the interests of the Association would not suffer by such action; therefore, be it

Resolved, That we, the National Electric Light Association of America, representing in our midst every department of electric light and power industry, express our deep regret at the decision of Mr. Morrison not to allow us to keep him at the helm, where, through many storms and quick-sands, through much fair weather and some foul, he has successfully guided us to the haven where we now find ourselves; and be it further

Resolved, That a vote of thanks be given to Mr. Morrison for the disinterested devotion, enthusiasm and steadiness with which he has administered the affairs and presided over the proceedings of our conventions; and that, further, we tender him our best wishes for his deserved enjoyment through a long and prosperous life, of the beautiful prospect of the great work he has done in founding, fostering and cherishing the National Electric Light Association.

The resolutions proposed by Dr. Moses were seconded by Mr. Duncan and were unanimously carried, and three cheers given for Mr. Morrison.

Mr. MARTIN offered the following resolution:

Resolved, That the resolutions adopted in regard to the invaluable services of Mr. J. F. Morrison as President for three years be suitably engrossed and presented to him, and that a committee be appointed to carry out this work and to make the presentation.

The resolution was adopted, and Mr. Martin and Dr. Moses appointed a committee to carry it out.

A vote of thanks was also given to Mr. H. Metzger, manager of the Pittsburgh Telephone Company, for the instrument placed at the disposal of the convention.

Mr. DE CAMP: I would like the privilege of offering the following resolutions:

Whereas, In the death of Mr. W. S Frear, secretary of the Brush Company, of Buffalo, N. Y., the association has sustained a severe loss;

Resolved, That the association hereby expresses its deep regret at being deprived of the fellowship and counsel of so young, promising and active a member, and that it further hereby tenders its sincere condolence to the many friends and the family of the deceased.

Resolved, That the secretary make the communication of the above to those who have been thus sorely bereaved.

The resolutions were seconded by Mr. Martin and adopted.

The discussion on underground wires was then again taken up by Messrs. Wright, Leggett, De Camp, Smith and others, and the Convention finally adjourned *sine die* at 5 P. M.

NOTES.

Among the pleasant social features of the Convention were dinner parties given by Mr. S. A. Duncan and Mr. R. T. McDonald, and theatre parties given by Mr. W. F. Swift and Mr. J. L. Barclay.

Following its usual custom, THE ELECTRICAL WORLD published its Bulletin of the proceedings of the convention, and issued three editions, one daily, immediately after each adjournment, from Parlor 8.

It should perhaps be stated that even more editions would have been issued but for the fact that two of the days were holidays—one being election day and the other Washington's Birthday; and those who are acquainted with printing offices will appreciate the difficulties of the situation, when the work had to be done 500 miles from home.

With some little extra exertion, however, the *Bulletin* was put forth with wonted promptitude, and nearly 4,000 copies were issued for use of the convention and general circulation.

A great many members visited the Bentley-Knight electric railway, now in operation in the out-skirts of Allegheney City, running up Observatory Hill, climbing up precipitous heights and winding around the sharpest curves. This road has already been described and illustrated in THE ELECTRICAL WORLD, and promises to become one of the best known in the country. Its execution is a splendid piece of pluck and an excellent piece of engineering. Although all were impressed with the ease with which the car with a full load of passengers lifted itself up long steeps with grades of 10 per cent., perhaps the most interest was felt in the working of the conduit section. The smoothness and ease with which this part of the road was handled was regarded by everybody as a good augury for the successful operation of the Fulton street road, New York, where the Bentley-Knight conduit system and rolling stock equipment are to be used.

The chief points of interest to those in attendance at Pittsburgh were the various places at which are carried on the great industries with which the name of Westinghouse is so prominently connected—the electrical factory, the machine works, the switch and signal works, the air-brake factory, the underground cable factory, the natural gas plants, etc. Each of these establishments was thronged from the beginning of the convention until its close by the members, who came away with a vivid idea of the magnitude of the operations carried on at the bidding and initiative of one whose name now represents in all parts of the world so many leading developments of American inventive genius and skill in mechanics. The output of Westinghouse engines, it was stated, since 1882 is no less than 2,900 engines of an aggregate of about 140,000 H.P. The first engine of the familiar type now represented at one end by the "Junior" and at the other by the large new compound, is carefully kept in the office at the machine works. It is understood that Mr. Westinghouse is working on a rotary engine. Of the work at the electrical factory little need be said, as the rapid growth of the alternating current business has already become a twice-told tale. Visitors were shown freely through all parts of the factory, even to the inner recesses of the lamp department, and were enabled to see the alternating dynamos and the converters in all stages of preparation.

It was probably at these establishments that many of the members saw natural gas for the first time in actual use in the industrial arts, the gas being burned under the boilers as well as in different parts of the works for the most varied purposes. It was easy to see at a glance the cheapness and the cleanliness of the gas as a fuel and an illuminant, and to understand how eagerly the people of Pittsburgh had welcomed the change from the soft coal

whose flame and smoke once made their bustling city resemble "hell with the lid off."

The gas, it may be added, was found burning not only under the boilers at these works, but also at the station of the Allegheny County Light Company, and at the electric railway station mentioned elsewhere. It is due to the Westinghouse companies to say that every courtesy was shown by them to the members, and every facility extended that could add to the enjoyment of their guests.

EXHIBITS.

Mr. W. M. Talcott, in Room 39, represented the Hawkeye Electric Manufacturing Co., of Oskaloosa, Ia., manufacturers of dynamos, lamps, etc.

Mr. Walter S. Clark represented the Crosby Steam Gage and Valve Company, of Boston, with a display of gages, indicators and steam whistles.

Jas. W. Queen & Co., the well-known instrument importers and makers of Philadelphia, placed on exhibition in Parlor 8 a number of Ayrton & Perry voltmeters and ammeters.

The headquarters of the Westinghouse Electric Company were Rooms 35 and 36, where delegates were received and all who desired were given an opportunity to visit the works of the company.

The Baxter Electric Manufacturing and Motor Company and the Sun Electric Company were represented by Mr. Frank Ridlon, at Room 9. Specimens of the lamps made by the Sun Electric Company were on exhibition.

The Solar Carbon and Manufacturing Company, of Pittsburgh, was represented by Mr. C. B. Curtis, of Chicago, in Room 8, were he exhibited a full line of electric light carbons and specimens of carbon in its natural state.

In Room 25 the Eddy Electric Manufacturing Company, of Hartford, Conn., had a 100 volt motor, and besides exhibited a Warner's patent electric gauge. Messrs. A. D. Newton and M. E. Baird were the representatives.

The Simplex Electrical Company, Boston, exhibited in Room 34 the Simplex insulated wires and tapes for electric lighting purposes. Mr. A. F. Mason was in attendance. Over 125 miles of these wires are now in use in Pittsburgh alone.

The C. & C. Motor Company, N. Y., was represented by Messrs. H. L. Lufkin and G. W. La Rue, who had on exhibition in Room 40 two ½ h. p. motors, one running a sewing machine on an arc light circuit and the other operating a ventilating fan on an incandescent circuit.

The New York Insulated Wire Company had quarters in Room 47, where its energetic agent, Mr. J. W. Godfrey, made a full and interesting exhibit of Grimshaw white core insulation in wires both stranded and solid. Another specialty shown was the Grimshaw splicing compound.

The headquarters of the American Waltham Watch Company was Room 9, and the exhibit, which comprised a full line of non-magnetic and other goods, was looked after by Mr. H. E. Duncan. This company manufacture a non-magnetic watch and, besides, alter watches of their own make to render them non magnetic.

The Edgerton Electric Motor Company, Philadelphia, exhibited in Room 31 a direct acting electric pump in actual operation, and a combined motor and fan. They also had on exhibition a sub-circuit guard or automatic cut-out for motor circuits to hold intact the main electric circuit. Mr. N. H. Edgerton was in attendance.

The Falls Rivet Company, Cuyahoga Falls, O., had on exhibition in the corridor a friction clutch of the Brock patent, manufactured by them, which attracted a great amount of attention from the delegates. Mr. E. D. Schmidd explained the working and construction of the clutch to all. Mr. E. L. Babcock, the president of the company, was also present.

Holmes, Booth & Haydens, of New York, manufacturers of the patent K. K. insulated copper wire for arc and incandescent lighting, were well represented in Room 28 with a line of samples, which comprised, besides the K. K. wire, underwriters' electric light wire, flexible cord and magnet wire. J. L. Barclay and Theo. Larbig were in attendance.

The Callender Insulating and Waterproofing Company was well to the fore in Room 32, being represented by Mr. W. M. Callender himself, as well as by Mr. A. W. Butterworth. In connection with its display of butte and Trinidad insulating specialties, the company distributed its new and very tasteful catalogue, one of the neatest and best publications of its class, giving a large amount of information as to the products of the concern.

In Room 37 the Okonite Company were found, with Messrs. W. L. Candee and G. T. Manson as sponsors. As the *Scientific American* of last week contained an interesting illustrated description of the manufacture of okonite wire and cables, the delegates were able on obtaining a copy to learn much that was interesting in regard to the manner in which another important industry has been developed by the advance of electrical applications.

The Campbell Electrical Supply Company, represented in Room 39 by F. E. Clark and C. I. Hague, exhibited a general line of its insulated wire known as the "Vulcan," intended for telephone, telegraph and electric lighting purposes. It is "proof" against a variety of evils known to electric circuits and is meeting with general favor. It has just been adopted for the police signal system of the city of Boston. The company are about to increase their manufacturing facilities.

Mr. C. K. Giles, of Chicago, had on exhibition at Room 8 a full line of watches fitted with his "Anti-Magnetic Shield," and running alongside of large magnets without variation. Mr. Giles gave some very instructive talks to electricians on the merits of his invention in neutralizing the electric influence upon watches. The watches protected by this shield at the tests made when the delegates visited the works of the Westinghouse Electric Company proved entirely satisfactory

The exhibit of the Bernstein Electric Light Manufacturing Company, made under the direction of Mr. H. B. Cram, consisted of incandescent lamps in series, with arc lights and motors, and included the new cut-out which forms a part of the lamp socket, and is specially constructed to meet the exactions of high tension currents. All outside parts of the lamp and socket are of insulating material. The lamps are 25, 50 and 100 c. p., and the same socket can be used at pleasure with any of them.

The Standard Underground Cable Company, Pittsburgh, in Room 42, displayed a full line of their well-known cables, as well as some new departures in the line of cables, among which may be mentioned the W. A. C. wire, which is fire, water, weather and acid proof; also their weather-proof line wire, and many others whose merits are too well known to need special mention. Messrs G. L. Wiley, of New York, and F. E. Degenhardt, of Chicago, the managers East and West respectively, represented the company.

The Electrical Supply Co. of Chicago displayed in Parlor 10 a complete line of electric light supplies, reels and coils of their well known P. & B. weather-proof wire, spools of magnet wire of various sizes, coils of silk and cotton covered duplex conductor and tinsel cords, fine sizes German silver resistance wire, brush copper, annealed iron lamp cord, circuit loop breaks, street, loop and group switches, cleats, connectors, testing sets, Wirt voltmeters, the Piper testing battery, Diamond carbon batteries, in fact, samples of everything they manufacture. F. DeLand was in attendance.

The Geneva Non-Magnetic Watch Company, represented by Mr. Addison Conkling, exhibited in Room 38 a full line of movements in solid gold cases. These goods are made in complicated as well as plain goods, including chronographs, repeaters and calendars. All are rendered non-magnetic by the use of the Paillard balance and spring, and were shown to withstand the influence of the strongest dynamos. Special interest was taken in the exhibit from the fact that one of the papers read had called attention to the merits of the watch in a very favorable manner, as being sure to remain accurate and true under the most exacting conditions.

The Phœnix Glass Co., of New York, displayed a complete line of globes and shades for both arc and incandescent lighting and suited for all systems. Their exhibit of incandescent globes, which was in charge of Mr. A. H. Patterson, in Room 41, comprised some entirely new features and effects of a really artistic character, among which may be mentioned rich cut glass, decorated and etched, also in the more staple lines of opal, etc. This company considers the electric field of such importance as to have a special department in their large works devoted to this interest exclusively. The company have an office at 43 Sixth avenue, Pittsburgh.

The interests of the E. P. Gleason Manufacturing Company, of New York, were looked after by Mr. W. F. Cullen. The exhibit in Room 33 was brilliantly illuminated with incandescent lamps arranged on elegant combination chandeliers and brackets of the most improved construction and latest designs, which showed to excellent advantage the various styles of rich cut, etched, opal globes and shades used for electric lighting. There was also an exhibition of metal appliances, such as insulating joints, tin shades, wire guards, Gleason's improved socket clamp globe holders arranged for any system of incandescent lighting, etc. Mr. Cullen and his company deserve great credit for the enterprise exhibited in the display of almost every sort of fixture in the glass and metal line used in connection with electric lighting.

The exhibits would not have been complete without a conduit, and this was furnished by the National Conduit Manufacturing Company, of New York, represented by J. P. McQuaide, in Room 39. By means of this wrought-iron cement-lined conduit wires can be distributed to each and every house in a block, while the non-conducting non-absorbent lining preserves the iron from rust and decay. Among the other miscellaneous exhibits were the excellent lava insulators of the D. M. Steward Manufacturing Company, of Chattanooga, represented by Mr. G. C. Steward in Room 8; the cells of the Union Indurated Fibre Company; the Diehl sewing machine motor, in which the motor is housed in the fly-wheel; the Frisbie friction clutch represented in Room 8 by W. M. Frisbie; Hafner's anti friction system for dynamo driving; and the platinum of Baker & Co., of Newark, represented by C. O. Baker, Jr.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
168-177 POTTER BUILDING, NEW YORK, Feb. 27, 1888.

The Gibson Electric Light Company.

Among the companies which have recently come to the front and about which there is not a little inquiry, is the Gibson Electric Light Company, of 45 Broadway. The corporation has for its president Mr. D. H. Bates, so well known as a leader in the telegraphic field. Mr. H. McDowell is its secretary, and Mr. C. McC. Smith its treasurer. The name is taken from Mr. C. D. P. Gibson, the inventor of the Gibson storage battery and other appliances. Mr. C. L. Clark, formerly of the Edison and Telemeter companies, is the consulting electrician. The present factory at Hudson and Bank street will not be occupied after May 1, as the capacity is so small that the company have had to refuse orders, and a new factory is being prepared in Jersey City. The company are now filling a large order for the Daft Company, and the cells are to be used on the Eighth Avenue road.

The Stratton Separator.

I note that many of the most prominent electric light companies appreciate the advantages of the Stratton separator, which insures safety from the bursting of cylinders and heads in high speed engines, which is to be feared wherever there is any condensation of steam in the pipes, or wherever there is a foaming boiler or much variation in the drafts of steam so frequently produced by switching on or throwing off any considerable number of lights.

The Electro-Engraving Machine.

Mr. G. F. Whelpley, of Albany, N. Y., practical engraver and instructor in engraving, represents the electro-engraving machine illustrated in the last issue of THE ELECTRICAL WORLD.

Bridgeport Lathes.

Mr. E. P. Bullard, of the Bridgeport Machine Tool Works, informs me that the Edison Electric Light Company are using two Bridgeport lathes, and that a number of the lathes and other machines and tools have been sold for use in Mr. Edison's new laboratory. The display of the various productions of the works, seen at 72 Warren street and 62 College place, is quite instructive. The concern are sole agents for Brown & Sharpe, and furnish a large number of specialties.

The Shaver Corporation.

This company, of 157 Broadway, are bringing out several highly ingenious novelties. Outside the office is their new electric show case, in which to the amusement and delight of thousands of passers by an endless banner is carried over rollers, so as to exhibit at any one time announcements about 18 × 24 inches. The rollers are operated by a little electric motor at the top of the case. The corporation are also bringing out an electric typewriter, an acoustic telephone, a time card for offices, a neat little pocket typewriter and a "magic wheelbarrow," which will return nickels dropped squarely on its tray, but appropriates all that are put in crookedly.

W. T. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
48 Congress Street, Boston, Feb. 27, 1888.

Personals.

Mr. and Mrs. Gardiner C. Sims, of Providence, R. I., are enjoying a trip through the South.

Mr. A. F. Upton is recuperating in health and strength under the orange trees of Florida.

A Gas Company to Purchase an Electric Light Franchise.

It is reported that the New Bedford, Mass., Gas Light Company will issue $75,000 new stock to purchase the franchise and plant of the New Bedford Electric Light Company. The latter company are using the Thomson-Houston system.

Blodgett Bros. & Co.

Messrs. Blodgett Brothers & Company, the well-known manufacturing electricians of Boston, have removed their factory and offices from No. 63 Kilby street to No. 383 Federal street. The new quarters are conveniently located, commodious, and equipped with new machinery.

Reflectors for Electric Lights.

The Wheeler Reflector Company, of Boston, has furnished 20 cars of the Intercolonial Railroad (Canada) with its popular reflectors, for use on the incandescent lamps. The Julien storage batteries—the same as in use on the Boston & Albany trains—furnish the current. Owing to the use of the Wheeler reflectors, a less number of incandescent lamps are required to illuminate the cars in a satisfactory manner. This meritorious reflector is beginning to be appreciated and extensively used by incandescent electric light companies.

Dinner of the Boston Electric Club.

The Boston Electric Club held its monthly dinner at the Thorndike Hotel, Saturday evening, Feb. 18, about 100 gentlemen being seated at the tables. In the absence of President Alexander, W. J. Denver, General Manager of the New England Telephone Company, presided. Among the guests were Rev. Edward Abbott, of Cambridge; George F. Parmelee, President Edison Light Company, of Topeka, Kan.; Calvin A. Richards, formerly General Manager and President of the Metropolitan Street Railway Company; A. V. Abbott, of New York; Thomas D. Lockwood, of Boston, and Sidney Cushing, of Boston. After the coffee had been served, the presiding officer, Mr. J. Denver, rapped for attention and introduced Mr. A. V. Abbott, of New York, who, it had been announced, would read a paper on "An Explanation of the Boston Heating Company's Plant." Mr. Abbott, who is the Chief Engineer of the National Heating Company of New York, proceeded, not to read a paper on the subject, but to deliver a most comprehensive address without the aid of manuscript. The speaker described minutely the system of the Boston Company, from its origin to the perfected construction at the present time. A number of the members of the club took the 11 o'clock train on the Boston & Providence Railroad, over the shore line, for Pittsburgh, there to attend the National Electric Light Convention.

W. I. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
39 South Tenth Street, Philadelphia, Pa., Feb. 25, 1888.

A. F. Moore.

Alfred F. Moore, the well-known manufacturer of wire, reports a good business for this season of the year, although the very high price of copper has interfered with it to some extent. Copper has increased in price from a fraction of nine to nearly seventeen cents, and this has caused users of wire to purchase their supplies in a sort of "hand to mouth" style. While the volume of business in dollars and cents is just as great as usual the sales are much less, as only immediate wants are provided for.

Partrick & Carter.

Messrs. Partrick & Carter, in their new catalogues, call especial attention to a new annunciator, which embraces a guest time call attachment and a general fire alarm, in addition to room call. With the guest call any room can be called at any designated hour, and it is a valuable addition. They are made of any size from twenty numbers up, and in any desired style. This firm have so improved their own make of disque Leclanché battery that they believe it to be the best open circuit battery on the market, and they have decided to handle only this style.

The Philadelphia Electrical Society.

The first annual reception of the Philadelphia Electrical Society was held last Wednesday night in the new rooms of the

club, at 1712 and 1714 Chestnut street. The rooms were prettily decorated with bunting, plants and flowers.

An audience of 800 persons was present. One of the pleasing features was the large number of pretty girls, any number of whom were to be seen at every turn. A sale of packages was made during the intermission in the entertainment. A hop wound up the festivities of the night. The committee in charge of the entertainment was C. M. Knapp, E. E. Starr, C. D. Shrieves, C. R. Reynolds, W. K. Fox, W. O. Snyder, J. S. W. Phillips, L. S. Kates, J. J. Walsh and G. H. Olin. E.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD.
44 Lakeside Building, Chicago, Feb. 25, 1888.

The Chicago Rawhide Manufacturing Company.

The Chicago Rawhide Manufacturing Comnany have just shipped a complete outfit of belting, including their special dynamo belt, to the Brush Electric Light Company, Nashville, Tenn., being the second order received from this company.

The Brush Electric Company.

Mr. Alex. Kempt, the manager of the Chicago branch of the Brush Electric Light Company, reports that he is very busy at the present time in taking contracts for this system.

The Central Electric Company.

The McKinlock Bros. have just taken the Western agency of the Butler Hard Rubber Company, of N. Y., and announce that they have a very large and complete stock of this class of goods on hand. They have just issued a neat little catalogue of the specialities in this line for distribution. They furnish the Okonite wire with which the new Heffron & Gore Building on Clark street is to be installed. They are also supplying large quantities of Okonite wire to be used in the lighting of railway cars by storage batteries, and they inform me that the demand for this well-known wire for this purpose is increasing. E. L. P.

BUSINESS NOTICES.

Jordan & Gottfried, 208 Canal St., N. Y., carry a complete stock of iron and brass machine and wood screws, bolt cap and set screws, taps, dies, files, twist drills, brass and rubber tubing, rod and sheet copper, brass, German silver, steel and iron wire, shafting, tools, etc.

Hine & Robertson, 45 Cortlandt street, N. Y., are pursuing a novel method of inducing electric light companies to try "Eureka" Packing. To every new customer ordering direct from them 15 pounds or more at regular price, 75 cents per pound, they will send a handsome 8-day calendar clock, 12 in. dial, 24 in. high, or a set of brass oilers and tray, 6 pieces, the best made. This is an easy way to secure one of these necessary articles and at same time get a packing indorsed by very many prominent electric light plants.

Mr. W. H. Lahman, of 158 Lake street, Chicago, manufacturer of the Lahman Improved Kirkwood shaking and dumping grate bar, reports a good and steadily increasing demand for these well-known bars for use in electric light plants. He has recently put them in plants for the Thomson-Houston Chicago Arc Light and Power Co., Freeport Electric Light Co., and other systems. They are also in use in the United States Goverment Buildings, Custom House, Post-Office and Marine Hospital; in all the court houses and county buildings, Opera House, Rialto, United States Express, Palmer House and many other large and well-known buildings in Chicago and elsewhere.

The Wainwright Manufacting Company, of Boston, manufacturers of corrugated tubing, feed-water heaters, expansion joints, etc., have, during the last year, placed their heaters in many prominent electric light stations in this country and abroad, having 1,000 h. p. in successful operation in stations in Japan. By the use of corrugated copper tubes in their heaters they gain largely in heating surface, strength and absorption of expansion and contraction over the ordinary heater constructed with plain tubes. Their circular No. 13, just issued, will be promptly mailed upon receipt of inquiry, illustrates seven styles, which the manufacturers are now prepared to furnish.

PERSONALS.

Mr. F. C. Newhall, Manager of the Newhall Sugar Refining Company, of Philadelphia, is now President of the Ball Electric Light Company, of New York.

Mr. Fremont Wilson has accepted the position as superintendent of the Julien Electric Traction Company, with uptown office at Eighty-fifth street and Madison avenue, this city.

Mr. F. S. Terry, manager of the Electrical Supply Co. of Chicago, and Mr. F. W. Parker, the patent expert of the same city, were among the visitors to the office of THE ELECTRICAL WORLD last week.

Mr. E. V. Cherry, vice-president of the Standard Electrical Works, of Cincinnati, is spending the winter in California for the benefit of his health. He is expected in Cincinnati again about the middle of April.

Mr. H. G. Rich, superintendent of electrical agencies of the Standard Electrical Works of Cincinnati, was in New York last week. He says the Hess Hotel guest call system, manufactured by the Standard Electrical, is meeting with much and growing success. The well-known Post magneto bells are also still turned out in large numbers to meet the steady demand for them from telephone companies.

Mr. S. S. Wheeler has furnished for a special supplement to *Harper's Weekly* of Feb. 25 a copiously illustrated article on "Recent Developments in Electricity as an Industrial Art." Mr. Wheeler is one of the foremost young electrical engineers of the new school, and shows himself thoroughly well equipped for lucid explanation of the many new electrical inventions that are already becoming household words. It is encouraging to see so good an article on the subject in so representative and widely circulating a paper.

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

PATENTS DATED FEBRUARY 14, 1888.

377,137. Automatic Temperature Regulator; Warren S. Johnson, Milwaukee, Wis. Application filed April 9, 1887. An arrangement of heater, damper, valve motors and thermostats, the last mentioned being located in different apartments. The heat regulating damper is operated only when all the apartments reach the same given temperature.

377,851. Electric Fuse; P. G. Gardner, North Adams, Mass., Assignor of one-half to R. Penniman, Dover, N. J. Application filed April 14, 1887. The wire which becomes incandescent to do the firing is embedded in a shield of explosive solid matter.

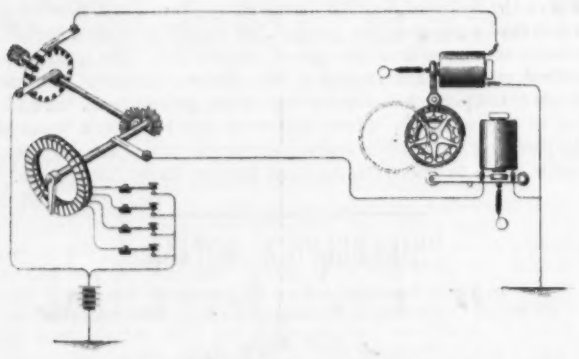
377,894. Support for Electric Conductors; M. J. Hart, New Orleans, La. Application filed Dec. 6, 1887. Towers placed at long intervals support heavy cables, and on the cables are erected trusses which carry the insulators for the conductors.

377,953. Tubular Metallic Pole for Telegraphic and Other Uses; A. Mills, U. S. Army, Assignor of one-half to N. A. Mills, U. S. Army. Application filed March 14, 1887. The pole is in sections and the joints are strengthened by the insertion of a sleeve between the ends of the sections, making three thicknesses.

PATENTS DATED FEBRUARY 21, 1888

378,078. Conductor for Electrical Fire-Alarm Systems; W. A. Barnes, Bridgeport, Conn. Application filed Sept. 26, 1887. A wire composed of lengths or sections of a metal fusible at a low temperature, the sections being united by joints formed of a metal fusible at a temperature still lower than that at which the wire sections will melt.

378,107. Printing Telgraph; D. E. Pike, New York, N. Y., Assignor to Western Union Telegraph Company, same place. Application filed July 8, 1886. An arrangement of mechanism whereby the press mechanism is operated when the type wheels are brought into position for printing any



378,107. PRINTING TELEGRAPH.

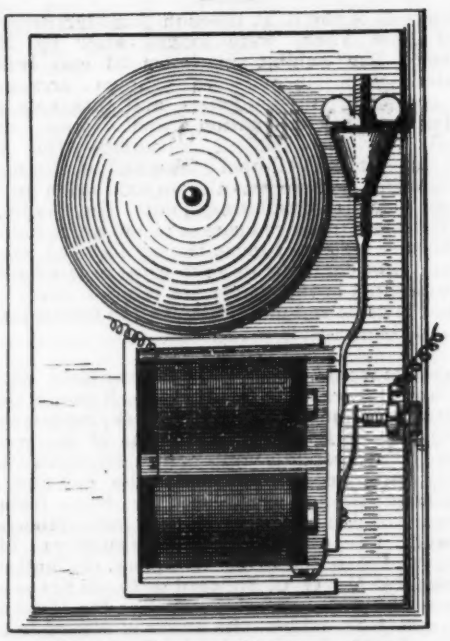
desired character without arresting the rotating pulsator or suspending the step-by-step rotation of the type wheels. See illustration.

378,115. System of Electrical Distribution by Secondary Batteries; J. S. Sellon, Hatton Gardens, County of Middlesex, England, Assignor to the Electrical Accumulator Company of New York, N. Y. Application filed Aug. 30, 1887. Storage batteries at the station are placed in circuit with the working lamps. Each lamp and each cell of battery is provided with a magnet adapted to operate its armature under a current of a certain number of ampères. The operation of the armatures cuts in or out the lamp or cell to which it belongs. Thus, if the lamps and the magnets which control them run on 20 ampères, they will be cut in when such a current is flowing and the cells will be cut out because their magnets do not respond to a 20 ampère current. This arrangement will allow of the charging of the battery while the lamps are not running.

378,121. Galvanic Battery; H. Walter, Cincinnati, Ohio, Assignor to the National Galvanic Battery Co., of New York. Application filed Sept. 20, 1886. A hermetically sealed jar containing pulverized carbon and a solid electrode of carbon. The zinc is inclosed in a wrapping of absorbent material to separate it from the carbon.

378,122. Galvanic Battery; H. Walter and W. E. H. Marsh, of Cincinnati, Ohio, Assignors to the National Galvanic Battery Company, of New York, N. Y. Application filed May 12, 1887. The usual porous cup is glazed or made non-porous and then perforated to allow the passage of the solution. The pulverized carbon is prevented from falling through the perforations by a lining of cloth.

378,124. Electro-Magnetic Bell; J. Wetzler and S. Wetzler, Hoboken, N. J. Application filed Jan. 28, 1887. The hammer or striker is in the general shape of a cone, and is



378,124. ELECTRO-MAGNETIC BELL.

mounted upon the lever arm by a screw connection between the parts. The striker is normally located upon the arm, so that contact will be made with the gong at a point on the striker about half way between its extremities. A movement of the striker up or down will alter the distance between the gong and striker, and serve as a mode of adjusting those parts. See illustration.

378,175. Telegraph Cable; W. R. Patterson, Chicago, Ill., Assignor to Western Electric Co., of same place. Application filed Nov. 17, 1887. The invention consists in first drying the core of the cable, then saturating it with paraffine in alternate sections and then covering the core thus prepared with a water-proof covering. The result is a cable provided with a core of insulated conductors, saturated at alternate sections and covered by a water-proof sheathing. See illustration.

378,181. Multiple Telegraphy; C. Selden, Baltimore, Md. Application filed April 15, 1887. The disturbances commonly called "tailings" are overcome by composing a part of the line of arc circuits with graduators arranged in them, and a derived line connected to the main line by separators. A condenser branch connects the line to ground.

378,183. Mechanical Telephone; N. B. Stubblefield and S. C. Holcomb, Murray, Ky. Application filed Feb. 19, 1887. A drum is mounted on a base board and the diaphragm is stretched over the drum. The button is on the outside of the diaphragm and is connected with line by an eye which passes through the diaphragm.

378,250. Telephone Switch; J. R. H. Hinton, Baltimore, Md. Application filed June 3, 1887. The device consists of an insulating roller, contact springs operated by the roller, and a grooved bracket within which the hook moves and is guided in the act of removing and suspending the telephone. The movement of the telephone shifts the contact springs and makes the usual changes in the circuits.

378,258. Manufacture of Incandescent Electric Lights; T. Mace, New York, N. Y. Application filed Feb. 15, 1887. A carbonizable thread is saturated with an oxygen-bearing compound of aluminum capable of being decomposed by the application of heat, and yielding thereby alumina. Heat is then applied, and the compound is decomposed, leaving alumina. This treatment produces a filament of higher incandescing power.

378,259. Electric Railway; C. T. Mason, Assignor to the Maryland Electric Motor Manufacturing Company, of Baltimore, Md. Application filed Jan. 22, 1887. A system in which one rail transmits the current to the motor and the other returns it. The rails are laid in alternate sections of insulating and conducting material, so that shocks may not be delivered to animals or persons coming in contact with both rails.

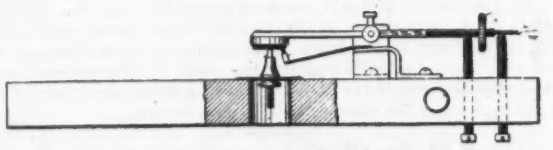
378,298. Telephonic Transmitter; M. G. Farmer, Eliot, Me. Application filed Nov. 2, 1887. Besides the main electrode an independent conducting point of relatively small mass is electrically connected to one of the terminals of the transmitter and in permanent yielding contact with the electrodes of the opposite terminals. This prevents the "sputtering" sometimes heard. See illustration.

(1) 378,320. Alternating Current Transformer; (2) 378,321. Transformation and Distribution of Electrical Energy; R. Kennedy, Glasgow, Scotland, Assignor of one-half to R. Dick, same place. Applications filed respectively April 6 and 20, 1887. (1) The rapid reversals of the current in transformers cause a great deal of loss by heat in the magnetic iron. This is overcome by winding the core with a wire carrying a continuous circuit, which maintains the magnetism of the iron in one direction, the effect of the usual

378,175. TELEGRAPH CABLE.

primary and secondary being to increase or decrease the magnetism without changing its direction. (2) To obtain the maximum self and mutual induction in secondary generators for the purpose of self-regulation, the conductors are wound in numerous short lengths or small sections, each of a few turns, and each section with an independent short magnetic circuit, so that they lie almost equally close to the iron core and outer sheathing throughout their length.

378,332. Telegraph Key and Instrument; William A. Melbourne, of Swanwick, Ill. Application filed Oct. 15, 1887. The particular feature of novelty in this case is the



378,398. TELEPHONIC TRANSMITTER.

arrangement of the key in connection with two main lines, so that it may be switched on to either.

378,358. Incandescent Electric Lamp Fixture; Harry M. Doubleday, of Columbus, Ohio. Application filed Sept. 23, 1887. A non-conducting disc having electrical connections and a shell having means of ready attachment to the disc and adapted to support the pendant conducting wires of the lamp.

378,375. Core for Dynamo-Electric Machines; W. C. Rechniewski, of Paris, France. Application filed Dec. 8, 1887. The plates of the inducing electro-magnets are stamped out from the same sheets as are employed to make the core of the armature.

378,385. Telephone-Receiver; A. W. Brown, Evanston, Wyoming Territory. Application filed April 7, 1887. Instead of the usual diaphragm a tongue is arranged to vibrate between the poles of a U-shaped magnet.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1866—can be had from this office for 25 cents. Give the date and number of patent desired, and address Johnston's Patent Agency, Potter Building, New York.